An Investigation of Saudi Science Teachers’ Perceptions and Implementation of Inquiry-Based Learning

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Abstract

The main aims of this study were to explore Saudi science teachers' understandings and beliefs about inquiry-based learning (IBL) and their implementation of IBL in science in Saudi schools. The study also aimed to identify the challenges associated with IBL practice in science in Saudi schools. A mixed methods design was employed, with three types of data collection methods: classroom observations, interviews, and online questionnaires. Data were collected from science teachers across different school levels (primary, middle, and high). Twenty-seven science teachers were observed and interviewed and a total of 288 science teachers completed the online questionnaire.

The findings indicate that science teachers hold a range of different understandings about IBL. Most participants did not have well-structured knowledge about IBL; rather they used very broad explanations such as 'researching and discovering'. Although most participants appeared to have inadequate knowledge about IBL, they held a strongly positive attitude towards it. The findings reveal that there were statistically significant differences in teachers' understandings and beliefs about IBL according to the school levels at which they taught. There were also statistically significant differences in teachers' beliefs about IBL and their perceptions of IBL challenges according to their specialisations.

IBL was rarely observed within the teachers' classrooms; furthermore, teachers' practices tended to be teacher-directed and very structured. The participants reported several factors that prevent them from implementing IBL including lack of resources, large numbers of students in classes, heavy teaching loads, students' lack of abilities, and content-heavy curricula. This study concludes that there has been a gap between the policy makers and science teachers that has hindered the successful implementation of IBL as an element of educational reform in Saudi Arabia. Teachers expressed a need for more support to enhance their knowledge and implementation of IBL.

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Author’s declaration

I hereby declare that this thesis is a presentation of original work and I am the sole author. No part of this PhD thesis has been previously published or submitted anywhere else. All sources are acknowledged as References.

Chapter 1: Introduction

1.1. Outline of the Aim and Purpose of the Study

This thesis aims to investigate science teachers' perceptions about inquiry-based learning (IBL) in Saudi schools. A new science education reform has been implemented in Saudi Arabia that relies on IBL as a pedagogy of teaching science. Since the adoption of American textbooks for science education, changing the teaching practice to accomplish this orientation appears to be a challenging process. It might be necessary for any change endeavour to consider different elements of the situation and to be carried out in a way that considers the mutual relations between multiple aspects such as teachers and curriculum materials. The requirement for teachers to move away from traditional teaching practices becomes a challenge to their personal beliefs. In addition, the literature shows that teachers face many challenges in applying IBL in the classrooms (more details can be found in the literature review chapter). Because teachers have a critical role in delivering the new science courses that depend on the IBL approach in the classrooms, their perceptions are significant to successfully achieve the government objectives. Therefore, this study seeks to investigate science teachers' perceptions of IBL and to obtain in-depth data about the current practice of IBL in teaching science in Saudi Arabian schools.

This chapter will contextualise as well as put into perspective the nature and origins of the research's problem and why this study is significant in the Saudi Arabian context. The contribution of the study to the research topic and the writer's personal interest in the topic will be discussed. The purpose of the study and research questions will also be introduced. Additionally, this chapter will provide a brief explanation of the research strategies and techniques. Finally, an overview of the structure of the thesis will be highlighted.

1.2. Background Information

There is continuous interest in science education debates for introducing new teaching practices because the traditional method of teaching provides students with inadequate skills for the twenty-first century. Minner, Levy, and Century (2010) delineate that traditionally science teachers deliver subjects as an accumulation of rules, laws, and facts and theories that students should memorise. Thus, typically, traditional teaching starts with a theory which then applies to practice (Prince & Felder, 2006). However, numerous researchers have demonstrated that traditional approaches of teaching science may result in minimal academic engagement and poor application of scientific concepts (Duit & Treagust, 2003; Gunel, 2008; Minner et al., 2010; Wilson, Taylor, Kowalski, & Carlson, 2010). Furthermore, researchers have stipulated that the teaching of science should turn to student-centred models such as IBL, where students take an active role, instead of a passive role in the traditional teacher-centred approach (Blanchard et al., 2010; Fensham, Gunstone, & White, 2013; Freeman et al., 2014; Haney, Czerniak, & Lumpe, 1996; Minner et al., 2010).

Accordingly, many countries in their national science education reforms have suggested the use of IBL for the teaching of science courses. To name but a few, the National Science Education Standards (National Research Council, 2000) in the United States, the England

National Science Curriculum (England Department of Education, 2013), and Australian Science Curriculum (Australian Curriculum Assessment and Reporting Authority, n.d.) have included IBL as an attempt to improve students' understanding of scientific concepts. Furthermore, some organisations such as the American Association for the Advancement of Science (AAAS), the National Research Council (NRC), and the National Science Foundation (NSF), have encouraged teachers to practice IBL in their classroom to develop science education (Minner et al., 2010). Saudi Arabia is among the countries that have emphasised that science teachers should use a form of IBL in the teaching and learning of science as one of their aims in the last educational reform introduced in 2008.

Despite these global initiatives for science educational reform, there has been little empirical evidence that investigates the profound nature of teachers implementing IBL into classrooms (Capps & Crawford, 2013). More importantly, there is no universal consensus on IBL that could lead stakeholders, policy makers and teachers, to interpret IBL in different manners (Anderson, 2002; Blanchard et al., 2010; Capps & Crawford, 2013; Capps, Shemwell, & Young, 2016). Additionally, researchers (Gillies & Nichols, 2015; Van Uum, Verhoeff, & Peeters, 2016; Yoon, Joung, & Kim, 2012; Zion, Cohen, & Amir, 2007) have indicated that the understanding of this concept as a critical factor for an effective implementation, and at a more fundamental level, has been a source of considerable challenge for science teachers.

Various studies pointed out that the teachers' beliefs and convictions toward IBL have a direct influence on the degree of implementation of such practice. Teachers' perceptions and beliefs may play a significant role in the implementation of a reform-based curriculum such as IBL (Alhendal, Marshman, & Grootenboer, 2016; Capps et al., 2016; Lee & Shea, 2016). Teachers' understanding may affect their decisions on teaching practices and the adoption of the new curriculum reform (Duffee & Aikenhead, 1992). According to Wallace and Louden (1992), failure to take into account teachers' beliefs and practices may result in a lack of success in the outcome of the reform efforts. Therefore, teachers' beliefs and knowledge of IBL may have a critical and direct impact on teaching practice. Even though teachers' beliefs could affect the use of IBL, Voet and De Wever (2019) emphasise that "there is little known about how these beliefs influence teachers' adoption of IBL" (p. 1).

IBL is a challenging area for researchers to explore, and it is not simple to make sense of it. The overriding reason for this is that there is no single agreed definition of IBL - indeed it is contested in the literature - and nor is there a single accepted way of implementing it. Therefore, it was likely in my study that participants might not have a shared understanding of IBL, and it was also possible that the literature on IBL could touch on a wide range of different understandings and practices. It became important, then, to identify a precise meaning of IBL that could be investigated. For the present study, I adopted the NRC (2000) definition of IBL to investigate Saudi science teachers' perceptions and implementations of IBL. The NRC (2000) definition of IBL was adopted because the current science textbooks in Saudi Arabia are based on a translation of an American series of science textbooks that were developed according to NRC's (2000) document.

1.3. Problem Statement

Saudi schools have historically favoured and have taught through a rote-learning system which relies heavily on memorisation and a unidirectional teaching style. As a result, there is a perceived status of the teachers in the society where they enjoy and expect full respect and obedience from the students. For example, during the teaching session the students are expected to listen and give full attention to the teachers and possibly deliver any questions outside of the teaching sessions. This modus operandi has deep historical roots in the Saudi educational system.

The desire to promote science and technology in Saudi Arabia required a transformation in the teaching of science, to raise it to the standards typical in developed nations. Policy makers in Saudi Arabia now seem more determined in moving towards a more proactive, holistic, student-centred, IBL for instructional delivery and they are very keen to move away from the old model perceived as quaint, with the objective of providing students with a different experience and learning outcome (Mansour & Al-Shamrani, 2015).

However, debate continues about the best strategies for the implementation of the reform initiative. Barab and Luehmann (2003) point out that a major challenge that science curriculum developers could face is the adaptation of a science curriculum in a way that meets the needs and goals of the culture. Similarly, Fullan (2007) and Mansour (2013) assert that the changes in the educational curriculum should consider the sociocultural contexts. The new science curriculum in Saudi Arabia, adapted from a completely different sociocultural context (American context), is perceived by the teachers as not related to their cultural and historical traditions and norms

(Alabdulkareem, 2016). According to Mansour (2013), “teachers’ beliefs and practices should be studied within the sociocultural contexts of their work because the relationship between their beliefs and practices is both complex and context-dependent” (p.1). Therefore, it is important for the Ministry of Education (MOE) in Saudi Arabia to take into account the cultural and social differences when adapting a Western science curriculum in order to lead to a positive perception for the science teachers. One way of achieving this could be to involve teachers in the decision-making processes about curriculum and pedagogy.

According to Ryder, Banner, and Homer (2014), frequently, science curriculum reformists report that teachers do not implement the reforms properly. One common reason that could lead to such “failure” is that the lack of teachers’ understanding of the scope of the reform as well as the motivation behind it (Ryder et al., 2014). Hence, in order to implement a curriculum reform successfully, teachers need to fully understand the objective and the scope of the new curriculum, and to develop their skills and deepen their knowledge about it (Ryder et al., 2014). The science curriculum reform in Saudi Arabia requires teachers to implement more progressive teaching approaches and have the ability to make an investigative classroom environment by using inquiry-based practices (EL-Deghaidy, Mansour, Aldahmash, & Alshamrani, 2015). However, do Saudi science teachers have adequate knowledge that would enable them to implement such reform? Do they fully understand the purpose and the scope of the new curriculum?

It seems that Saudi science teachers have not implemented a proper pedagogy that would fulfil the requirements of the new science curriculum (Almazroa & Al-Shamrani, 2015; El-

Deghaidy & Mansour, 2015; EL-Deghaidy et al., 2015). Aldahmash and Alshamrani (2012) noted that science teachers were still attached to the rote-learning method which suggests a possibility of weak alignment between the objectives of the policies and practices. Furthermore, researchers (e.g., Alghamdi & Al-Salouli, 2013; Althalabi, 2015) reported many other factors that could hinder the implementation of the science curriculum reform such as insufficient time, large numbers of students in a class, lack of professional development programs, necessary equipment and material, classroom and laboratory space, and administrative support.

In the Saudi context, there are hardly any academic studies on how Saudi science teachers perceive and implement IBL within classrooms. Rudolph (2005) claims that IBL is inconstant and can be variable under the phenomenon being examined. According to DiBiase and McDonald (2015) and Keys and Bryan (2001), more research is needed in the area of teachers' understanding and beliefs towards IBL within diverse urban educational environments. According to reviewed literature, teachers' interpretation of IBL varies within the same context this leads to an ongoing challenge to generalise their views (More details can be found in the literature review chapter). In a recent study, for example, Maass, Swan, and Aldorf (2017) found diverse interpretations of IBL held by teachers from 12 European countries. Since Saudi Arabia's sociocultural environment is quite different from the Western countries, this study has the potential to contribute to the understanding of IBL from a wider social context.

1.4. The Purpose of the Research

Since teachers are critical stakeholders in the curriculum reform process, the MOE in Saudi Arabia may need to develop strategies to support teachers and consider their perception towards IBL, with particular attention to their centralised system and top-down approach. In their role, the teachers are required to follow the textbooks and the teacher's guidebook supplied by the MOE for science instruction, learning activities, lesson plans and aims, and homework (Aldahmash, Mansour, Alshamrani, & Almohi, 2016). Van Driel, Beijaard, and Verloop (2001) argue that those involved in curriculum development that takes a top-down approach should plan how the curriculum should be reformed (in addition to what the reforms should be), as well as considering how the teachers will change their classroom behaviour and adapt to appropriate teaching practices. Therefore, the current research seeks to fill in the gap between those designing the curriculum and the teachers who are expected to implement the curriculum.

This study aims to investigate the teachers' perceptions of IBL and the pedagogy involved in their style of teaching and its appropriateness for IBL. The study will attempt to focus in particular on the Saudi context, looking at science teachers' beliefs and their own personal experiences of trying to use and implement IBL in the classroom, as well as examining the current teaching environment.

In looking at the issues involved, the study will not list the pros and cons of IBL, and then give its own opinion, nor will it attempt to prove or disprove theories of IBL. The objective of this study is two-fold: firstly, it will look at teachers' perceptions and beliefs of IBL as well as examine its practice in the classroom. Secondly, it will attempt to determine the degree or extent to which teachers are ready to use this approach and major addressable obstacles. Therefore, this study seeks to investigate the following aims:

1. To investigate Saudi science teachers' perceptions of inquiry-based learning.
2. To highlight Saudi science teachers' perceptions about the challenges they think potentially hinder/prevent inquiry-based learning.
3. To investigate Saudi science teachers' implementation of inquiry-based learning.

1.5. Research Questions

To achieve the research objectives, this study aims to address the following questions:

1. How do Saudi science teachers understand inquiry-based learning?
2. What are Saudi science teachers' beliefs about inquiry-based learning?
3. How do Saudi science teachers implement inquiry-based learning in the classroom?
4. What are the Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?

1.6. Rationale for Undertaking this Research

I am interested in this topic for several reasons. I trained in my bachelor's degree to be a science teacher. Then, I worked as a science teacher in the middle and high school stages for three years - I am a physics specialist, and I have taught general science. I then joined Taibah University as a lecturer and teacher trainer in science education between 2012 to 2014; my students are trainee science teachers, both primary and secondary. During my time as a science teacher, the reform introducing IBL was implemented and I observed that teachers were not clear and confident about what they were expected to do. As a lecturer, through my work with trainees, I also found that IBL seemed to be challenging for new entrants to the science teaching profession to understand and implement. I was awarded a scholarship in 2014 by Taibah University to complete postgraduate studies in the UK in science education, and chose to conduct a systematic research study to understand more rigorously these observations that I had made as a teacher and lecturer.

My role as a university lecturer and former science teacher is likely to facilitate productive research engagement with teachers in different ways. When I recruited participants, I introduced myself as a University Lecturer in science education; the culture in Saudi Arabia is such that they would conclude two things from this: firstly, that I have been a school teacher previously, and secondly that I do not work for the MOE. Therefore, my role would give me the advantage of being able to build friendly professional relationships with teachers, based on their trust that I understand the demands of the job they do (having experienced it myself) and on their appreciation that I am not currently a decision maker in the MOE, and nor do I represent them. Thus, teachers are likely to feel that they can express their ideas freely without feeling under the pressure of being assessed or of needing to provide answers that would be viewed favourably by the MOE. Also, my role as a university researcher offers me the opportunity to raise teachers' voices about the issues associated with the reform and to contribute to solving them. Therefore, it is expected that my situation should help secure productive engagement with teachers in this research, rather than hindering it through perceptions of being an authority figure.

My role as a university lecturer and former science teacher has enabled me to notice some issues that Saudi science teachers face during their careers. During my experience, I noticed that there is a lack of science teachers' voice in Saudi schools, and the MOE does not seem to be interested in engaging science teachers in the curriculum reform process. Also, science teachers, as stakeholder in the reform process, do not seem to have adequate knowledge to deliver the new curriculum effectively. Critically speaking, how such a reform would be implemented successfully without considering teachers' views and providing proper training, despite its significant differences in both content and teaching practice. Therefore, as IBL is the main instructional approach for delivering the science curriculum reform in Saudi Arabia, a major objective of this study will be to investigate science teachers' perception towards IBL and how to steer them into the desired mindset.

1.7. Research Design

A mix methods approach was adopted, and with a variety of data collection methods: observations, interviews, and online questionnaires were used to investigate the research questions. This study was conducted in three stages: the first stage was classroom observations; then the second stage was a series of semi-structured interviews with the same teachers observed in the first stage; the third stage was an online questionnaire covering a wider range of Saudi science teachers. The qualitative data was analysed using thematic analysis while descriptive analysis was used for the quantitative data. Also, appropriate statistical tests were performed to compare between different variables (gender, school levels, experience, and specialisation). Statistical Package for the Social Sciences (SPSS) software was used to analyse and present the quantitative data (more details in Chapter 4).

1.8. Structure of the Thesis

This thesis is organised into 10 chapters. It begins with an introduction in **Chapter 1**, providing the aim and the purpose of the study, the nature and origins of the research's problem, the significance of the research, the research questions, and a brief explanation of the research strategies and techniques.

Chapter 2 details the study context, and it aims to present a general background about the education system in Saudi Arabia and its current configuration. Also, it presents the statues of educational reform in Saudi Arabia. The historical and current changes in science education in Saudi Arabia are also highlighted. Most significantly, it discusses the adoption of IBL in teaching science in Saudi Arabia.

Chapter 3 presents a review of the relevant literature to the present study. It begins by discussing the definition of IBL and the possible distinction between IBL and other teaching approaches. This is followed by a section on teachers' beliefs and how this is related to the classroom practice with a focus on teachers' beliefs about science education reform and IBL. The chapter continues with a discussion of teachers' knowledge and implementation of IBL as well as the challenges of IBL implementation.

Chapter 4 focuses on explaining the research design. This chapter provides information about the research approach, data collection methods, and the rationale for the choice of instruments utilised in the three stages. It also provides information about the development of the research tools, research sample and setting, and the techniques of data analysis. Matters related to pilot studies, validity, reliability, and ethical consideration are also discussed.

Chapter 5 presents the findings related to the first research question which is about teachers' understandings of IBL. Interviews and online questionnaire findings are presented using tables, and figures. This chapter is organised into two major sections. The first section presents the findings obtained from the analysis of qualitative data while the second section shows the results obtained from the analysis of the quantitative data.

Chapter 6 aims to display the results of the second research question which is teachers' beliefs about IBL. It presents the findings of teachers' views about whether IBL is important and beneficial in teaching science. It begins by presenting the interview findings. This is followed by displaying the online questionnaire results. Tables are used to show the findings.

Chapter 7 highlights the findings related to the third research question which is about teachers' perceptions about the challenges of IBL implementation. The first section of this chapter presents the findings of the interviews while the second section shows the online questionnaire findings. The post-processed data are organised into tables for driving the discussions of the findings.

Chapter 8 presents the results of the final research question which is about teachers' implementation of IBL. This chapter is organized into three sections. The first section displays the findings of the classroom observation. The second section presents the interview findings. The final section shows the online questionnaire results. A comparison between the findings of classroom observations, interviews, and online questionnaires is also provided. Tables and charts are used to display the results.

Chapter 9 provides a discussion and interpretation of the study findings presented in the previous chapters. The study findings are discussed in the light of the research questions and related literature.

Chapter 10 is the final chapter which includes a summary of the main findings of the research. It also includes reflections on the strengths and limitations of the study, recommendations and directions for further research, and implications for practice.

Chapter 2: Study Context

2.1. Introduction

This study primarily focuses on IBL and how science teachers perceive it in the Saudi context. The review of the context issues may provide insight into the background and, therefore, highlight the significance of the research topic. Education in Saudi Arabia has encountered rapid developments in recent years which has turned the focus to teaching methods that are perceived by the MOE to be modern such as IBL. Thus, to understand both the status of educational reform in Saudi Arabia and the importance of this study, it is necessary to highlight the historical and current educational changes. Consequently, this chapter is intended to introduce a general background about the education system in Saudi Arabia including its policies and administrative bodies. Matters related to teaching requirements, teachers' preparation and in-service training are also presented. More importantly, the current status of recent educational reform in Saudi Arabia will be discussed with a focus on science education.

2.2. The Education System in Saudi Arabia

The school system in Saudi Arabia is composed of three stages (primary, middle, and high). The primary school level lasts for six years (ages 6 to 12). The middle school level lasts for three years (ages 12 to 15). The high school level lasts for three years (ages 15 to 18). The Saudi government provides free education for all general school stages. Furthermore, it is compulsory for pupils to attend primary and middle stages (Ministry of Education, 2017a). The teaching staff and school buildings are strictly segregated by gender at all levels. However, both male and female students receive the same curriculum. Textbooks are chosen and provided by the MOE and they are recognised as the main source for learning and teaching. The adopted textbooks are considered as the national curriculum in the country. In other words, there is no separate national curriculum document.

In Saudi Arabia, the educational system is predominantly centralised and regulated by the MOE. This is a top-down approach with a strict focus on processes and procedures, emphasising stringent administrative control within its overarching educational remit. Policy makers make decisions about educational processes, i.e., national educational initiatives all are formulated in higher governmental corridors of power. The MOE uses its leverage to administer the managerial aspects of the educational requirements. For instance, it controls matters pertaining to educational budget, professional development programs, coordination of school year calendars, the provision of in-service professional training, the assessment of teachers' performance, and the supervision of school administrations in all K-12 levels of schooling (Alsonble, Alkateeb, Motoaly, & Abdu-aljawad, 2008). Students' progression requirements and the assessment system are also organised by the MOE (Alaqeel, 2013; Alsonble et al., 2008). Moreover, the required textbooks and the way of teaching are determined by the MOE except for universities.

Nevertheless, schools have very little power to intercede into the school system in Saudi Arabia. Therefore, Alsayegh (2007) points out that the current state of high-level control of the educational structure in Saudi Arabia has catered for parity and proactive progression in tandem with national education. On the other hand, it has translated to meagre educational transformation and innovation hence generating a mediocre transition into the implementation of modern and varied pedagogical methods (Alsayegh, 2007). This view is also supported by Al Mofarreh (2016) who found that the centralised system is one of the factors that has hindered the implementation of the recent change in ICT (Information and Communication Technology) policies in Saudi schools.

The centralised system of the MOE in Saudi Arabia may influence teachers' strategies and implementation of the curriculum. Teachers are required to implement the curriculum and instructions provided by the MOE for all stages of general education (Alghamdi & Al-Salouli, 2013). The curriculum and teaching approaches are commonly adapted or developed from international sources, modifying them to meet the goals and needs of education in Saudi Arabia. Alghamdi and Al-Salouli (2013) argue that since the implementation of the curriculum falls to school administrators and teachers, their personal experiences and beliefs could impact on their practice in classrooms.

Teachers in Saudi Arabia dominate classrooms and have control over students - students are expected to obey teachers fully. These are cultural expectations in Saudi society. For example, teachers control matters including, but not limited to, delivering classroom instruction, organising and managing classrooms, assessing and grading each student, offering feedback, giving students tasks and homework, and choosing exam questions. These cultural expectations tend to reinforce transmissive pedagogical practices, where the teacher is seen as the source of all knowledge and the students' role is to receive this wisdom in passive obedience.

However, teachers have to follow headteachers' instructions and the MOE's guidance. For example, headteachers set the school timetable and the school's approach to discipline, within which teachers must work, and they are responsible for annual appraisal of teachers. Teachers should implement curriculum requirements as provided by the MOE and they will be evaluated against that in their appraisals. So, the top-down approach influences the education system in Saudi Arabia.

Since the education system is under the control of the MOE, all schools are obliged to adhere to the standards that underpin the national curriculum. Also, educational materials in every subject area are specifically selected by the MOE and offered as free to all students and teachers in each academic term (Al-Eissa, 2009). The same subjects are taught in all general levels of education apart from high school, but the subjects' contents are mainly different in each level. The main subjects taught in Saudi schools are religion, languages, mathematics, science, history, arts, and sports. Furthermore, the MOE organises the academic year into two broad terms of the duration of 14 weeks, respectively. Teachers are expected to cover the scope of the prescribed textbooks within the specified stated term. All lessons are 45 minutes long and the number of lessons a week depends on the school stage.

With regards to matters relating to students' assessment, continuous (periodical) and traditional examination assessment criteria are employed in the school system of Saudi Arabia (Alhareth & Dighrir, 2014). The continuous assessment system is used to assess students' performance at the primary level. In this kind of assessment, teachers are requested to evaluate students' progress in the form of periodic tests during the academic term (Alhareth & Dighrir, 2014). Therefore, students who reach the minimum target skills can be transferred to the next level. In contrast, as far as Saudi middle and high schools are concerned, assessment is primarily contingent on traditional examination scenarios. As for each academic term, two rigorous exams are carried out to gauge student performances, entailing a mid-term and a final examination (Alhareth & Dighrir, 2014). Thus, students receive grades based on their performance in exams at the end of each academic year. Written and oral formats of assessment, that are designed and administered by teachers, are commonly used (Alhareth & Dighrir, 2014).

2.3. Educational Reform in Saudi Arabia

The Saudi context is characterised by rapid economic development, influential and integral religious belief, and strong social relationships (Mansour & Al-Shamrani, 2015). The Saudi government has recently devoted more effort than they did before to reform the education system to achieve socio-economic development goals and the 2030 vision. According to Mansour and Al-Shamrani (2015), the Saudi context has been considered in the literature as an emerging scope of research given the fact that it is experiencing an accelerated educational development, as well as, adopting and adapting extensively policies from Western countries.

In Saudi Arabia, the purpose of education was to transfer and preserve the traditional culture. In contrast, the government has introduced the Saudi “Vision 2030”. One of the core themes of the Saudi “Vision 2030” is the development of education. The policy makers have given a broader view of the aims of education as they consider education to be an essential element in developing several aspects of the country such as the economy and society (Ministry of Education, 2017b). In response to Saudi "Vision 2030" the MOE launched eight objectives of education to be achieved by 2030 as follows:

- Ensure quality, equitable and inclusive education for all residents and promote lifelong learning opportunities.
- Improve teachers' recruitment, training, and development.
- Improve the learning environment to ensure that it stimulates creativity and innovation.
- Improve the financial efficiency of the education sector.
- Develop the curriculum, teaching methods and assessment.
- Enhance the values and skills of students.
- Strengthen the capacity of the education and training system to meet the national development requirements and labour market needs.
- Increase the participation of the private sector in education and training (Ministry of Education, 2017b).

Nevertheless, educational change in Saudi Arabia faces a critical issue: how the nation could accommodate the innovation whilst maintaining their traditional values (Bahgat, 1999). For that matter, Rogers (2003) claims that "every social system has certain qualities that should not be destroyed if the welfare of the system is to be maintained" (p. 412). He proposes that the attitudes, beliefs, and values of a specific context are more influential for that culture than others, so, the education system should be determined in the light of cultural characteristics. Consequently, the decision makers should not impose a standard of innovation that is adapted from a different culture (Rogers, 2003). Aydarova

(2013) investigated the implementation and the impact of transferred curriculum and educational practices in the United Arab Emirates. The outcomes of Aydarova's (2013) study show that "the significant actors' interpretations of the local culture, context, and students' abilities play a central role in modifying, reducing, or substituting the transferred curriculum" (p. 284). Therefore, it is necessary for the policy makers in Saudi Arabia to take into consideration the sociocultural differences and the perceptions of stakeholders, particularly teachers, when adapting a Western policy.

Hamroun (2009) maintains that even though the MOE in Saudi Arabia has tried to improve the quality of general education, the way of implementing these efforts is ineffective. He argues that the current lack of enactment of educational reform may be due to the centralised system of the MOE. To illustrate, the regulation of schools has not been amended for more than 25 years, and neither has the fundamental teachers' support, such as teachers' preparations programmes and in-service professional training, been improved for several years (Algarfi, 2010; Alsayegh, 2007).

Furthermore, when IBL was introduced through curriculum reform, there was no associated change in students' assessment. This could also contribute to a lack of effective implementation of the reform, as teachers (and headteachers) may feel that pre-reform pedagogical approaches were securing strong student outcomes and therefore did not need to be changed. In Saudi Arabia, teachers and schools are judged on and held accountable for their students' assessment outcomes. Assessment is known to be a strong driver of teaching practices in such educational systems (Millar, 2013). The next section will focus on science education reform in Saudi Arabia as it is the main theme for this research.

2.4. Science Education in Saudi Arabia

Science is taught compulsorily at all stages of general education. In the primary and middle school stages the science curriculum is taught as a general course, but the middle stage has four sub-sections (physical science, chemistry, earth science, and life science). In the high school stage, the science curriculum is more extensive, including four separate courses (physics, chemistry, biology, and geology). Science education in Saudi Arabia was established in 1926 (Alosaimi, 2013), and since then, several development projects have been implemented. The following information will highlight some of the significant changes in science education in the Saudi context.

2.5. Science Education Reform in Saudi Arabia

Modern education systems have evolved in the Western countries and many parts of the world in what can be viewed as a top-down approach. The objectives are set by the education administrators who are following government policies for the education system, and this dictates the design of a curriculum and then the development of textbooks to implement the curriculum. It is a process to systematically achieve the policy objectives. Hence, the curriculum evolves as the objectives of the educational policies change overtime. Countries such as the UK, France, Singapore, and most of the developed countries follow this structured process for their education system (Boujaoude & Dagher, 2008). However, there are countries that do not follow this approach where the policy either has ambiguous objectives or simply translates to identifying a modern education system around the world that could be inherited from the textbooks to achieve the same level of education outcome. In this approach, the curriculum design and development receive less attention due to lack of a systematic process in the educational systems and government policies. As a result, modernisation focuses on textbook adoption for certain subjects from another country that is understood to be modern. Saudi Arabia is an example of a country that uses this approach for its education system. Textbooks supplied by the MOE are the only curriculum structure that exists in Saudi Arabia.

In general, the curriculum is something that is imposed on teachers by education administrators with little input from them. This is even true in many developed countries and the teachers are expected to implement the curriculum. In education systems such as Saudi Arabia where textbooks are central to curriculum delivery and pedagogy, a curriculum committee that includes the teachers should devote considerable time to review textbooks and the planning for any modernisation of the textbooks. Since the teachers rely on the textbooks they teach in the classroom, any addition of more tasks into the curriculum or changes to what is being taught by the educational administrators require the teachers' full awareness and acceptance. Therefore, teachers' involvement throughout any reform process could enhance chances for successful curriculum change, identifying and determining textbooks and the scope and the sequence of implementing the change.

The mid-1970s marked the beginning of the standardisation and development of science education within the Kingdom of Saudi Arabia. This was led by curriculum development experts in the field of science from the American University in Beirut (Aldahmash et al., 2016). Based on the available literature and historical data, the first science curriculum implemented in the kingdom appears to have had the objective of adopting the science textbook to be taught in the schools (Al-Abdulkareem, 2004; Aldahmash et al., 2016; Mansour & Al-Shamrani, 2015).

This approach of delivering science education has evolved relatively smoothly by simply adopting new textbooks from other countries into the country without any formal process to review curriculum implication or state of the policy of the government. The approach was relatively successful because the classroom delivery requirements from the teachers for the newly adopted textbooks remained the same. The evolution took a leap step in 2008 because the status of the country's science education was criticised as being inadequate with regard to the country's vision (Aldahmash et al., 2016; Alghamdi & Al-Salouli, 2013; Almazroa, Aloraini, & Alshaye, 2012). Aldahmash et al. (2016) argue that science textbooks before 2008 did not reflect two important aspects: (1) the needs of students, and (2) the need to meet the future vision for the social and economic development as well as cultural coherence of Saudi society. The core issue was pointed to primarily for its teacher-centred approach which focuses on pedagogies that encourage memorisation of scientific concepts instead of the understanding of them.

Alghamdi and Al-Salouli (2013) further mention that this curriculum did not motivate students to acquire knowledge through inquiry-based learning and critical thinking skills due to a minimal number of practical activities in the science curriculum. Along with these criticisms, the findings of the Trends in International Mathematics and Science Study (TIMSS) in 2003 and 2007 indicated that Saudi students' performance in science was lower in comparison to their peer countries in the region and globally (EL-Deghaidy et al., 2015; Mullis, Martin, & Foy, 2008). As a result of these challenges along with new developments in science education, such as the American science education standards and scientific literacy (American Association for the Advancement of Science, 1993), science education in Saudi Arabia has attracted even more attention from the policy makers than it had before.

The policy makers in Saudi Arabia received the critique constructively and initiated a master plan to shop around the world for the latest developments in science education. In 2008, an initiative called “Mathematics and Science Curriculum Development Project” was implemented in Saudi Arabia. The MOE decided to adapt, from its perspective, the most modern international series of mathematics and science curriculum to all stages of general education (primary, middle, and high), and to benefit from international experience in this field (Ministry of Education, 2009). It was envisioned that the students would develop abilities and skills to gain a deep understanding of the scientific concepts, formulate new concepts, enhance problem-solving and communication skills, innovate and develop products, and use technology in accordance with international standards (Ministry of Education, 2009). The project’s stated objective was to build a society that can meet the needs of the labour market and community values in Saudi Arabia, and as a result enable it to compete on a global scale (Ministry of Education, 2009). The Ministry of Education (2009) articulates that the aims of the “Mathematics and Science Curriculum Development Project” are based on several principles: including student-centred approaches, inquiry-based learning, cooperative learning, knowledge exchange, thinking skills development, communication and multi-representational knowledge, and a multi-approach learning. The following are the objective set forth by the Ministry of Education (2009):

1. To adopt the latest standard and research findings reached by institutions and centres of mathematics and science education worldwide.
2. To develop mathematics and science curriculum and other supporting materials (e.g., textbooks, teachers' guidebook, experiments booklets) in alignment with developed countries.
3. To take advantage of the leading experts in their fields and those who specialised in the production of supporting educational materials and the use of technology in the implementation of mathematics and science curriculum in general education schools.
4. To provide continuous professional development for teachers, supervisors, and curriculum experts in Saudi Arabia in different areas including the international standards and philosophy base of mathematics and science curriculum development, methods of teaching, assessment, classroom management, and integration of technology in learning.
5. To improve students learning in accordance with the principles of active learning and self-learning, as well as allow students accessible and constructive knowledge.

The Saudi’s MOE decided to adopt the USA science series textbooks to achieve a comparable level for its science education. These textbooks were translated from editions of the Science: A Closer Look series (for primary school) and Glencoe Science series (for middle and high school) which were produced by the American publishing company McGraw-Hill. These adopted textbooks were designed specifically to meet the requirements of the National Science Education Standards (NSES) in the USA (McGraw-Hill Education, n.d.-b). The pedagogical framework of these textbooks is based on IBL and student-centred approach. According to McGraw-Hill Education (n.d.-a), Glencoe Science and Science: A Closer Look series was designed in the light of the “new science standards with a curriculum that promote inquiry and real-world problem solving with phenomena and hands-on activities” (para. 1). They also state that these series encourage inquiry-based and student-driven learning (McGraw-Hill Education, n.d.-a, n.d.-b). The Saudi’s MOE emphasises that the philosophical basis on which the adopted textbooks were built is to provide multiple opportunities for students to practise scientific inquiry at its various levels, structured, guided, and open (Ministry of Education, 2018).

The K-12 McGraw-Hill science textbooks and their associated teacher guidance were modified and translated into the Arabic language by a local private company “Obeikan Research Development Company”. Due to the nature of this agreement, there is no available information of who was involved and to what extent if any teachers were represented in this process. The new science textbooks were envisioned that they will help the policy makers in Saudi Arabia to achieve their new vision for the kingdom’s science education (Ministry of Education, 2018). However, the new textbooks relied on the implementation of IBL in teaching science that required a fundamental preparation of the school administrators, principle, classroom facilities and the teachers that will be tasked to deliver the science subjects.

Although the MOE in Saudi Arabia has adopted new science textbooks, this reform is not well documented. The only available official sources regarding the teaching and learning of these textbooks are the student's textbook and teacher's guidebook. The trial edition of the student's textbooks and teacher's guidebook was introduced in 2009. Then, the revised edition was introduced in 2012, while the final edition was issued in 2014 and it is used up to date. For example, the teacher's guidebook mentions that the MOE in Saudi Arabia emphasises a student-centred approach such as IBL in order to help students to understand scientific concepts rather than memorising them (Ministry of Education, 2013). The MOE also had the objective to achieve meaningful learning by linking science to students' lives and experiences (Ministry of Education, 2013). In addition, the teacher's guidebook claims that teaching science through inquiry helps students to formulate their own knowledge. Furthermore, it states that IBL encourages students to discover, formulate questions and hypotheses, plan investigations, evaluate and reach conclusions (Ministry of Education, 2013). Moreover, it claims that IBL activities enhance and expand the learning process (Ministry of Education, 2014c).

Even though there was a vision and policies behind this initiative, there was no formal review of the curriculum and its link to achieve this vision. Rather, the same approach that was taken in the 1970s appears to have been taken again by simply adopting textbooks without having a formal curriculum process which revolutionised the science education in the kingdom. This simplistic approach of modernising the science education overlooked the critical dependency of IBL as required teaching approach to deliver the new science textbook to the classroom. The MOE was responsible for implementing the new science education after the textbooks were developed and it was aware of the requirement of IBL, but it appears to have expected the teachers will change their approach as soon as the textbooks change with minimum effort to prepare them. The MOE provided a guidebook for teachers. Also, there were workshops for some science teachers to introduce the new textbooks and how it should be taught in the classroom. However, it does not meet the prerequisites of the adopted textbooks (Almazroa et al., 2012). In addition, the dependencies of the adopted textbooks to be delivered in the IBL approach was not clearly conveyed. As a result, science teachers in Saudi Arabia may have developed their own perception and understanding of IBL which hindered the potential success of the outcome of the science education system.

2.6. The Adoption of IBL in Teaching Science in Saudi Arabia

In Saudi Arabia, teaching science through IBL was emphasised in the last curriculum reform in 2008 when IBL was identified as a pedagogical framework for teaching and learning science. The science syllabus has been designed to be more focused on IBL. The role of the teacher in these textbooks tends to be a leader and facilitator of the learning process. Also, science teachers need to understand and implement different teaching strategies such as IBL, problem-based learning, and inductive approaches to learning (Al-Ghamdi, 2013). Therefore, the instructional method of the adopted science textbooks tends to be a much more student-centred approach. Moreover, it requires Saudi science teachers to shift from a deductive approach to IBL and from teacher-centred to student-centred learning (Alghamdi & Al-Salouli, 2013).

IBL was prompted for learning science in the Saudi context to achieve the following aims: 1) to educate the new generation to be capable of solving the problems in their society as well as to efficiently contribute to the development of their country; 2) to develop students' abilities and skills to gain a deep understanding of the scientific theories, formulate new concepts, enhance problem-solving skills (Alshaya & Abdul Hamid, 2011).

The policy makers in Saudi Arabia emphasise a belief that teaching science through inquiry helps students to formulate their own knowledge. Also, they state that IBL encourages students to discover, formulate questions and hypotheses, plan investigations, evaluate and reach conclusions (Ministry of Education, 2013). In addition, they claim that IBL activities enhance and expand the learning process (Ministry of Education, 2014c). Although they have not mentioned any specific evidence of these claims, it is in accord with other research. For example, Chang and Mao (1999) found that IBL improves students' achievement and attitude towards science because it enables students to plan their own investigations, solve problems, share information, gather and interpret data, analyse findings, and reach a conclusion on the basis of evidence and reasoning. Moreover, the outcomes of Marx et al. (2004) study illustrate that there was a statistically significant increase in understanding of content and process, and overall achievement of students who participated in IBL curriculum units. Meta-analysis research conducted by Furtak, Seidel, Iverson, and Briggs (2012) also shows that there is a positive correlation between IBL and students' learning of science.

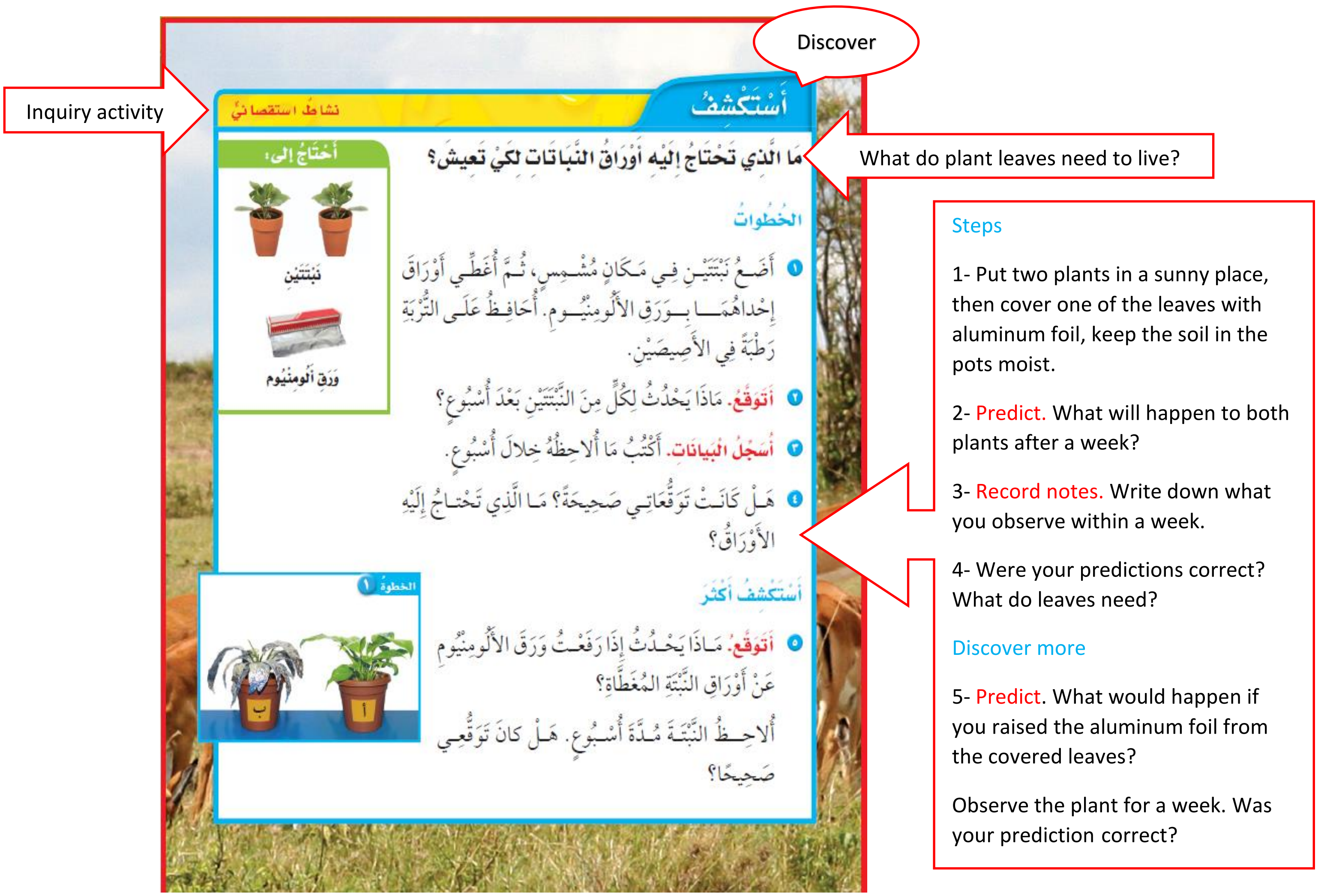
The MOE provides teachers with guidebooks to assist them in delivering the adopted textbooks. Through these guidebooks, teachers receive instruction and teaching strategies for every lesson. For example, the teacher's guidebook mentions that the teaching process of the adopted science textbooks in primary school's level is organised according to the 5E inquiry cycle model (Ministry of Education, 2014c). Accordingly, it is anticipated that primary school teachers should implement elements of the 5E inquiry cycle model as defined in Bybee et al. (2006, p. 8) which comprises five phases: engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 2006; Ministry of Education, 2014c). Bybee et al. (2006) and Ministry of Education (2014c) clarify the five phases of 5E inquiry cycle as follows:

- The engagement phase, where students are engaged in the learning task by raising questions, eliciting their prior knowledge, making them curious about concepts and topics etc.
- The exploration phase, where students are given the opportunity to develop ideas, generate and investigate questions and gather information, by providing them with challenging tasks.
- The explanation phase, where students demonstrate and justify their understanding of concepts and ideas in a clear, simple, and direct manner.

- The elaboration phase, where students apply and extend the concept being explored to a new or a similar situation.
- The evaluation phase, where teachers assess students' understanding of the new concepts.

It can be observed that IBL is a central part of the pedagogical approach espoused in the adopted science textbooks in Saudi Arabia. According to the Ministry of Education (2013), the student's textbook and teacher's guidebook are concerned with IBL activities in the classroom. Many characteristics and activities of IBL have been highlighted in the adopted science textbooks. For example, biology textbook for grade 10 highlights that IBL includes the following steps: asking a question, forming a hypothesis, collecting data, analysing data, and reporting conclusions (Ministry of Education, 2020a). In addition, the teacher's guidebook indicates that IBL is a problem-solving model, based on the questions and queries raised by students with an emphasis on cooperative learning strategies (Ministry of Education, 2014a, 2014b). Furthermore, the teacher's guidebook for grade 7 mentions that IBL gives priority to students to learn and practise the processes of science, whether they have designed their own experiences (open-inquiry), or have followed predefined action steps (guided-inquiry) (Ministry of Education, 2013). It also emphasises that the implementation of IBL is an actual practice of science which encourages and develops problem-solving and critical thinking skills (Ministry of Education, 2013). Moreover, the teacher's guidebook states that IBL makes students actively participate in the learning process by allowing them to identify the materials, tools, work steps, topics and questions they wish to investigate (Ministry of Education, 2013, 2014a). It also indicates that IBL helps students to develop a hypothesis, experiment planning, data collection, and analysis (Ministry of Education, 2013). The following are translated examples of IBL activities taken from science textbook for grade 2 and teacher's guidebook for grade 7:

Example (1): IBL activity taken from science textbook for grade 2 (Ministry of Education, 2020b, p. 31)



Example (2): IBL activity taken from science textbook for grade 7 (Ministry of Education, 2013, p. 9)

تجربة استقصائية   بديلة

الربط مع واقع الحياة اطلب إلى الطلاب العمل في مجموعات صغيرة لتطوير دليل لتصنيف المعادن، بحيث يمكن استعماله في المتحف الطبيعي المحلي أو في الميدان أو مع الطلاب في صفوف المرحلة الابتدائية. على الطلاب أن يحددوا طرائق فعالة للتواصل بالمعلومات؛ وذلك من خلال نشاط العصف الذهني، ومن ثم يعرضوا الأدلة التي أعدوها أمام زملائهم.

حل المشكلة

Experimental inquiry

Connecting with real life: Ask students to work in small groups to develop a metal classification guide that can be used in the local natural museum, in the field, or with students in primary school. Students should identify effective ways of communicating information through brainstorming activities and then present the evidence they have prepared for their colleagues.

Because Saudi science textbooks were adopted from the American context, IBL activities align with the definition of inquiry introduced by the National Research Council (2000). For instance, activities such as making observations, posing questions, planning investigations, using tools to gather, analyse, and interpret data are all included in the Saudi science textbooks. Aldahmash et al. (2016) examined Saudi Arabian middle school science textbooks' coverage of the essential features of scientific inquiry as defined by the National Research Council (2000). They found that 59 % of the analysed science activities cover aspects of the essential features of inquiry. Although there is no clear definition of IBL in the Saudi context, it is generally described as an approach based on student-led learning. Also, IBL is delineated as an umbrella term that incorporates many learning approaches including problem-based learning, discovery learning, and cooperative learning.

2.7. Conclusion

In spite of the fact that MOE in Saudi Arabia has highlighted the IBL as a necessary pedagogical approach to teach science, the implementation of such practice remains a challenge. Additionally, the student' achievement has not improved (Alyami, 2014). Indeed, the Saudi MOE did not consider teachers' perceptions towards the educational reform due to its centralised system (Alyami, 2014). The evidence suggests that Saudi science teachers' perceptions may have an influence on teaching practice. For instance, Alblaihed (2016) investigated science and mathematics teachers' perceptions about the integration of technology in the Saudi classroom. He found that teachers who did not use technology in their classroom assumed that the role of students should be more active, and the use of technology is not appropriate for the implementation of student-centred strategies. However, he also found that teachers who use technology still practice the traditional methods of teaching because they perceived that the transfer of knowledge to passive students through technology is their role. Therefore, comprehensive and intense support for teachers might be necessary to adopt profound and extensive changes to the teaching practices. Besides, it might be critical for policy makers to consider teachers' perceptions in order to implement educational innovations effectively (Al-Taneiji & McLeod, 2008). Moreover, Fullan (2007) argues that educational reform is a complicated process because it involves three significant dimensions that should be considered. These dimensions are related to beliefs, teaching approaches, and materials. Thus, it appears that there is an urgent need for a better understanding of the factors and circumstances that influence science teachers' attitudes towards IBL, and it could serve as a guide to plan and practise such an approach at all levels and conditions in schools.

Based on the top-down approach of the Saudi's MOE system, it is assumed that the educational reform will be transferred from the intended innovation to the implementation (Alyami, 2014). In this case, IBL has been incorporated into science education in Saudi Arabia. However, Maaß and Artigue (2013) demonstrate that the implementation of IBL is a complicated process which requires extensive knowledge of its concept as well as different execution and dissemination strategies (Maaß & Artigue, 2013).

A wide criticism of the top-down change approach has been made by many researchers (e.g., Guskey, 2002; Ryan & Weinstein, 2009; Veugelers & O'Hair, 2005) for the reason that it may fail to take into account teachers' experiences and knowledge, underrate the significance of teachers' practice to meet the local community needs, and because of a lack of full attention to the teachers' morale and investment in the innovation's implementation. Frost and Durrant (2002) emphasise that "too often [teachers'] roles have been constructed as relatively passive ones in which they are 'trained' to be able to implement a particular set of practices" (p. 144). According to Keys and Bryan (2001), "because the efficacy of reform efforts rest largely with teachers, their voices need to be included in the design and implementation of inquiry-based curriculum" (p. 631).

To sum up, it seems that the educational reform in Saudi Arabia was not put into practice after ensuring all critical success factors of the reform. In addition, the impact of this innovation in schools tends to be limited, which shows low progress (Alanazi, 2016). This might be because these efforts did not pay full attention to important factors such as teachers’ beliefs, teachers’ development, or resources. Numerous studies (e.g., Alkahtani, 2015; Alsaadi, 2016; Althalabi, 2015) confirm that the Saudi schools suffer from several aspects such as deficiencies in teachers’ preparations, teachers’ knowledge, professional development programs, and teaching resources. Therefore, the policy makers in Saudi Arabia may need to review their strategy for fulfilling the reform initiative and consider teachers’ perceptions as a crucial element in the change process. Also, there is a need to find out to what extent and how teachers apply IBL in their practice.

Chapter 3: Literature Review

3.1. Introduction

As stated in Chapter 1, the main aim of this study is to investigate Saudi science teachers' understandings and beliefs about IBL. It is also an aim to explore the implementation of IBL in Saudi schools and the challenges associated with its practice. This chapter provides a review of the existing literature that is related to the aims of the present study. This chapter begins by presenting an overview of the literature related to constructivism, which is a theoretical framework for understanding IBL. Subsequently, this chapter addresses the literature relating to the definition of IBL and to teachers' knowledge and beliefs about IBL. Literature related to implementation and challenges of IBL is also reviewed. This chapter concludes by considering the research literature related to the implementation of educational change since the present study is linked to implementing a new reform in Saudi Arabia, as detailed in the previous chapter.

3.2. Constructivism

In recent decades, pedagogies have increasingly valued active learning approaches, and the consideration of pupils' prior ideas and misconceptions. This evolution of practice has been paralleled by increasing discussion of the theoretical basis, which is constructivism (and social constructivism). Constructivism has influenced a variety of national curriculum and reform documents (Bada & Olusegun, 2015; Matthews, 2012; Taber, 2011b). Curricula that place emphasis on IBL are based on constructivism, which is a comprehensive theory that covers various teaching practices, including discovery learning, collaborative learning, and inquiry-based learning (Krahenbuhl, 2016; Makgato, 2012; Taber, 2011b). On the one hand, constructivism is considered as a learning theory, while on the other hand, it is perceived to be the basis of teaching approaches in which the specific focus is on constructivist (science) classrooms, which is applicable to IBL.

While the concept of constructivism is not a recent idea in the field of education, many researchers indicate that Piaget is the founder of the constructivist school in the twentieth century (e.g., Singh & Yaduvanshi, 2015; Sjøberg, 2007). The view of Piaget that knowledge is constructed in the minds of learners was derived from his study of the knowledge acquisition process in children (Muijs & Reynolds, 2017; Wadsworth, 1996). Subsequently, researchers began to perceive constructivism as a kind of learning theory that describes the learning of humans as a process in which they actively try to make sense of the world surrounding them (Taber, 2006). Taber (2006) listed four main features of constructivism as follows:

1. Previous knowledge: previous knowledge in constructivism is considered and utilised as a foundation based on which new knowledge can be constructed.
2. The knowledge is constructed: knowledge and ideas are not merely transmitted from instructor to students; rather, students form, build or construct their own comprehension that develop their existing ideas.
3. Learning is active: learners are actively prompted to develop their own knowledge in cases where learners take the initiative to learn themselves instead of merely being instructed on what they should know.

4. Learning is dependent on the physical or social conditions in which the learner exists (Taber, 2006).

The research base of constructivism is broad, which has enabled the development of numerous distinct types, definitions and notions regarding the nature of constructivism (Matthews, 2012; Sjøberg, 2007). Within the classroom environment, the most frequently referenced types that are employed when discussing IBL, which is the primary focus of the present research, are: (1) individual or cognitive constructivism, grounded in Piaget's theory, alternatively known as endogenous constructivism; and (2) dialectical or social constructivism, grounded in Vygotsky's theory (Matthews, 2012; Sjøberg, 2007; Taber, 2006).

The aforementioned two kinds of constructivism have commonalities and distinctions. Essentially, the core essence of social constructivism involves cooperative social interaction, whereas cognitive constructivism is based on an individual investigation (Muijs & Reynolds, 2017; Narayan, Rodriguez, Araujo, Shaqlaih, & Moss, 2013). Piaget advocated a cognitive-oriented approach and argued that learners construct knowledge on the basis of their activities in the world, which allows them to draw conclusions and form their own opinions (Muijs & Reynolds, 2017; Narayan et al., 2013). Piaget's approach is focused on the mental activity of the learner, while the intervention made by the teacher is comprised of establishing the most appropriate environment in which the learners can connect their prior and present knowledge to enable learning (Neaum, 2019).

From the perspective of Piaget, knowledge is a process instead of a condition, and is comprised of a relation among the individual who knows (learner) and that which is known (the knowledge). Within this relation, the learners construct their own perspective on the knowledge (Martin, 2012). Conversely, according to the approach of Vygotsky, the formation of knowledge is based on a social process, meaning that learning arises as the learner interacts with their social environment (Gray & MacBlain, 2015; Singh & Yaduvanshi, 2015). Vygotsky proposed that learning is reliant on cultural and social aspects, whereby learners (knowers) develop knowledge by socially interacting with one another. As indicated by Martin (2012), Vygotsky was an advocate of social constructivism who held the belief that learners have the ability to and should utilise others' input when formulating their construction and should not purely depend on themselves.

Although it appears that Piaget and Vygotsky had opposing views (due to the fact that Piaget considered that thinking develops in the direction of the individual to the social, whereas Vygotsky claimed that it occurs in the opposite direction), this is not in fact the case. Indeed, Piaget did not claim that the social sphere does not play a role in constructing knowledge, while Vygotsky did not disregard the individual's mental activity and ability to reflect (Cole & Wertsch, 1996). While both were constructivists, their thinking schools were differentiated by the fact that Piaget focused on the individual essence of learning, while Vygotsky placed emphasis on the social nature of learning. Commonalities included inquiry teaching approaches and the creation of concepts by learners on the basis of extant knowledge that has relevance and meaning, whereas distinctions included the theory of language development whereby, in the context of cognitive constructivism, thinking comes before language, and the opposite holds for social constructivism (Kalina & Powell, 2009).

Even though there is a broad range of versions, it can be contended that the theory of constructivism is generally acknowledged to be the most widely adopted and underpins the teaching reform in the field of science education in the contemporary society, while it has also been the focus of significant attention in recent years (Matthews, 2012; Taber, 2006, 2011b). This learning theory concentrates on the learner and the learning process, rather than the instructor delivering a lesson at a given time, the teaching objectives and the targeted behaviours of students or the needed proficiencies (Taber, 2011b). As a learning theory, constructivism is frequently contrary to the behaviourist model of learning, which is focused upon the efforts of learners to gather knowledge from the natural environment as well as the efforts of teachers to convey this knowledge (Fosnot, 2013; Singh & Yaduvanshi, 2015). Behaviourism primarily concentrates on the behaviours of students rather than their thinking processes; it is focused on individuality and suggests that behavioural modifications could represent the most pertinent results of the learning process when predetermined, repetitive feedback is given (Muijs & Reynolds, 2017).

Numerous scholars (e.g., Fosnot, 2013; Glasersfeld, 1995; Muijs & Reynolds, 2017) hold the common belief that according to the constructivist approach, learning is not a phenomenon based on stimulus and response; rather, it necessitates self-regulation and abstraction and concentrates on the development of concepts as well as profound understanding, where behaviours and proficiencies are not the main objectives of teaching. Hence, from a constructivist point of view, meaning should be constructed by learners themselves and, resultantly, learning occurs when it is linked to the learners' prior knowledge, conceptualisations or experiences (Martin, 2012).

To summarise, it should be recalled that although a large number of authors have focused on constructivism and the complex nature of its different forms, there is a general consensus regarding the need for learners to actively participate along with the universal acknowledgement of the social character of learning. As emphasised by Phillips (1995), almost all kinds of constructivism are contemporary types of progressivism which, when implemented in the context of teaching, dismiss the idea that information can merely be transmitted to a group of students with the expectation that learning will occur. Hence, the achievement of the educational objective of stimulating learners' thinking, leading to meaningful and more profound comprehension along with the transferal of knowledge to real-life situations, is feasible within a constructivist framework. This type of framework pertains to IBL, as it is recognised that a specific benefit of teaching based on IBL is that it allows learners to learn in a constructivist manner (Taber, 2011a). Those who support IBL propose that IBL has the potential to create the kind of environment where "meaningful science learning can occur" (Asay & Orgill, 2010, p. 57), as well as that learning via IBL corresponds to contemporary perspectives of learning psychology, which contends that students should be active participants in the learning process (Harlen, 2004). The next sections will discuss IBL.

3.3. Definition of IBL

IBL is a complex and contested phenomenon, so reviewing the literature on this field is quite challenging. It is difficult to focus a literature search and to reach conclusions about IBL due to the absence of consensus on its meaning, which results in different authors focusing on quite different aspects of curriculum and pedagogy. Furthermore, and probably partly as a result of contested understandings of IBL, there is disagreement in the literature about its purpose and value. The educational reform in Saudi Arabia which introduced IBL into the nation's science teaching was predicated on views about its purpose and value, though these are also contested in the literature. This section seeks to provide an overview of the meanings of IBL in the literature and discusses some key reasons why it can be so complicated to find a suitable working definition of it for a research study.

As the context of the present study is Saudi Arabia, it is useful to review the Arabic term used for IBL, which is استقصاء - "Istiqsa". Linguistically, "Istiqsa" means 'investigating and searching in depth and detail'. The use of the term "Istiqsa" in Arabic education is likely therefore to imply to teachers a student-centred pedagogy that focuses on exploration and finding things out. In other words, a pedagogy that allows students to research and carry out investigations. These meanings of IBL also are mentioned in the Saudi science textbooks as detailed in section 2.6, which is translated from Arabic to English. The Arabic literature on the topic of IBL depends on international sources to explain and define it. So, the following paragraphs discuss the definition of IBL from the broad literature.

Although IBL has been widely discussed in the literature, there is no clear agreement on its definition. According to Colburn (2000) “perhaps the most confusing thing about inquiry is its definition” (p. 42). The lack of reaching an agreed upon definition could stem from several reasons. For instance, NRC (2000) argue that the different interpretations of the nature of IBL and its implementation perhaps because every educator concentrates on a particular characteristic of it. Furthermore, IBL could be implemented for various academic subjects, and it may be found in diverse contexts as inquiry-based teaching, and inquiry-based learning, and scientific inquiry (Newman Jr et al., 2004). Similarly, Gyllenpalm, Wickman, and Holmgren (2010) claim that inquiry could be described in several ways in the curriculum reform discourse which makes its concept more confusion.

The first issue that could be found when researching about inquiry is its spelling. Both terms “inquiry” and “enquiry” are used to represent this approach in American and British English. However, “inquiry” and “enquiry” indicate the same meaning, which both based on questions asked by the investigator or learner, and only the matter of its spelling (Barrow, 2006; Watson, 2008). Another issue is the connection between IBL and scientific inquiry. According to Gormally, Brickman, Hallar, and Armstrong (2009), essentially, the term “inquiry” was used in order to promote the idea of teaching science in the way that scientists practise it as well as through problem-solving where students could test and formulate a hypothesis. Thus, IBL can be found associated with science inquiry in some studies which could allude to an assumption to the reader that IBL only can be used for science education. In addition, the term “scientific inquiry” is commonly used by educationalists and theorists interchangeably with “inquiry-based learning” or “inquiry”.

The National Research Council (1996) even connects the inquiry concept to science in the following quote: “inquiry is also a pedagogical approach that helps students achieve science understanding by combining scientific knowledge with reasoning and thinking skills” (p. 2). A possible source of the confusion between science inquiry and inquiry-based learning is the fact that the latter is generally associated with the learning of science and it is connected to science education (Anderson, 2002; National Research Council, 2000). Besides, the word of inquiry has a long-standing place for honouring science education since Dewey proposed it (National Research Council, 1996).

National Science Education Standards in the USA has emphasised inquiry as a learning and teaching approach (National Research Council, 2000). They attempted to clarify the concept of inquiry by proposing the following definition:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p. 23)

This definition is widely quoted in the literature which reflects what scientists do (e.g., making observations; posing questions) that is known as a scientific inquiry. In addition, it reflects how students learn and theories develop, and scientific ideas arise. It also reflects that students and scientists have the potential to learn from what they already know. It is thought that IBL refers to “all forms of scholarly exploration and investigation carried out by students as part of their studies or in extra-curricular contexts” (Minner et al., 2010, p. 7). Nevertheless, Bell, Smetana, and Binns (2005) argue that almost all pupils would need “substantial scaffolding” in order to be capable of formulating their own questions and designing procedures to find answers for their questions. This could cause difficulty for teachers since, from a Vygotskian point of view, scaffolding can be used to a certain degree when students develop new knowledge (Vygotsky, 1978). Therefore, it is critical for teachers to realise that scaffolding can be used where it is needed and to a certain degree in IBL practice.

National Research Council (2000) also published its version of ‘essential features’ of classroom inquiry to guide teachers as well as to distinguish between IBL in a general sense and IBL in scientific inquiry. National Research Council (NRC) identified the five ‘essential features’ of classroom inquiry as follows:

1- Learner engages in scientifically oriented questions.
2- Learner gives priority to evidence in responding to questions.
3- Learner formulates explanations from evidence.
4- Learner connects explanations to scientific knowledge.
5- Learner communicates and justifies explanations. (NRC, 2000, p.29)

Each of the above five essential features of classroom inquiry can vary from teacher-directed to student-directed, and these variations are based on the amounts of guidance and autonomy that are offered to students (NRC, 2000). Also, four levels of inquiry have been suggested by many researchers (e.g., Banchi & Bell, 2008; Riga, Winterbottom, Harris, & Newby, 2017) to distinguish between the different levels of guidance or support offered to students in IBL practice as follows:

1. Confirmation: in this level of inquiry students are provided with step-by-step instruction to verify a predetermined result.
2. Structured inquiry: in this level of inquiry students investigate an undetermined result but the instruction is also provided by the teacher.
3. Guided inquiry: in this level of inquiry students are only provided with a question or problem, but procedures of the investigation are designed and determined by students.
4. Open inquiry: in this level of inquiry students have full autonomy in choosing and designing an investigation.

Although the document of NRC (2000) has influenced science education worldwide, Abd-El-Khalick et al. (2004) discussed that a lack of agreement regarding the concept of IBL still exists between its philosophy and its practice as well as its objective in science education. Furthermore, the NRC (2000) discussed IBL and how it could be implemented into science classrooms from their context perspective, not from an international perspective. For instance, there are no European or Middle Eastern perspectives. Thus, an agreement for IBL definition and its characteristics remains challenging.

The various terms of inquiry could exacerbate the confusion regarding its conception. IBL has been mentioned in different terms such as inquiry-based learning, research-based teaching, and problem-based learning (Spronken-Smith & Walker, 2010). Anderson (1998) reported that the National Science Education Standards (USA) used different terms that relate to inquiry (inquiry teaching, inquiry learning, and scientific inquiry). Anderson (1998) states that scientific inquiry may refer to the way of scientific follow in order to investigate the natural world and formulate an interpretation of what they perceive. Anderson also reminds that scientific inquiry focuses on the way science works and could be viewed separately from the learning processes. However, IBL may refer to active learning which engages students in pursuing knowledge not only in science but also in different subjects (Anderson, 1998).

Indeed, these ideas could be developed from Dewey's work (Dewey, 1938) who mentioned the scientific inquiry method as the acquisition of knowledge through a discovery process. Dewey proposed that the role of teachers is facilitator and guide, while students should be taught through an active and student-centred approach (Barrow, 2006). In other words, students should simulate the scientist's approach when investigating natural science by doing and implementing experiments (Dewey, 1938). Dewey Further mentioned another type of inquiry called it as "common sense inquires". He distinguished between this type of inquiry and scientific inquiry by saying: it "occurs for the sake of settlement of some issue of use and enjoyment, and not, as in scientific inquiry, for its own sake" (Dewey, 1938, p.60). However, the foundation of these two kinds of inquiry is similar in which both of them are built on questions, obtaining an answer and reaching a conclusion. Thus, so far, IBL can be found in the literature directly related to science education. As a result of that inquiry-based learning could be overlooked in other disciplines. Dow (1996) emphasised that physical sciences have dominated the scientific inquiry debate in the educational field. Despite that, Dewey (1938) indicated that people might be engaged in IBL not only in science scope but also in various areas of life such as social issues.

A further issue regarding the definition of inquiry is whether IBL is a particular method of teaching and learning or just an umbrella that consists of several inductive teaching approaches. This could lead to another level of confusion that relates to the relationship between constructivism theories of learning and IBL. The latter has commonly been assumed that perhaps it is based on constructivism theories and could have one of its possible origins (Alake-Tuenter, Biemans, Tobi, & Mulder, 2013; Bybee, 1997; Cakir, 2008; Eick & Reed, 2002; Krahenbuhl, 2016; Liang & Gabel, 2005; Minner et al., 2010). Abd-El-Khalick et al. (2004) argue that several of the similar objectives are promoted by IBL and constructivism theory such as engaging students in experiences to construct concepts. Furthermore, IBL may also be a socio-constructivist approach that was proposed by Vygotsky. Vygotsky (1978) suggested that learning move from a social context to individual knowledge construction. Thus, students' work in pairs or groups is commonly implemented when using IBL (Barron & Darling-Hammond, 2010).

As indicated in section 3.2, one of the main perspectives of constructivist theory is that knowledge is constructed within the learner's mind and it builds on existing information to make sense of their world (Anderson, 2002). Practically, social constructivists suggest that students construct their knowledge by interacting with other people and the real world (Anderson, Greeno, Reder, & Simon, 2000). Although there are inconsistencies in interpretations of constructivism in current literature (Liu & Matthews, 2005), some common beliefs could be highlighted. Some of these beliefs are that students can learn more effectively when engaging in active and exploration learning, and in social and collaborative work (Gray & MacBlain, 2015; Muijs & Reynolds, 2017). Furthermore, inductive and interactive teaching methods should be implemented instead of the traditional approach (Prawat & Floden, 1994). Additionally, students should be encouraged to use hands-on materials and critical thinking as well as give an explanation of the facts instead of memorising and reciting it (Prawat & Floden, 1994).

Nevertheless, constructivism is a theory that describes the learning process, not a specific pedagogy and it has had a wide impact on teaching and learning methods (Orlando, 2013). As a result of that, the pedagogy builds on its philosophy which may interpret in various ways in practice. Therefore, a variety of inquiry phases and cycles are described in the literature. For instance, Bybee et al. (2006, p. 8) proposed an inquiry cycle that comprises five inquiry phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. On the other hand, White and Frederiksen (1998) proposed a five inquiry cycle, but begins with Question, Predict, Experiment, Model, and Apply. It appears that the first model starts with an inductive approach (empirical and data-driven), while the second model begins with a deductive approach (theory/hypothesis-driven). Thus, an inductive and a deductive approach can be found in inquiry cycle models (Pedaste et al., 2015). This could raise more confusion when teachers intend to select and to implement an inquiry approach.

Although this diversity in the concept of IBL, a common denominator about IBL characteristics could be highlighted. Many researchers (Colburn, 2000; Justice et al., 2007; Kahn & O'Rourke, 2004; Spronken-Smith, Angelo, Matthews, O'Steen, & Robertson, 2007; Spronken-Smith & Walker, 2010) are in agreement with the following criteria: (1) IBL stimulates the learning process whether driven by problems or questions. (2) Learning could occur through new understanding and construction of knowledge. (3) IBL is an active approach which involves learning by doing. (4) It tends to be a student-centred method in which students require more efforts for their learning and the role of the teachers as a guide or facilitator instead of a lecturer.

3.4. IBL in Comparison with Other Approaches

The diversity in the concepts of inquiry might be due to the conflation with other approaches. Anderson (1998) noted that since the 1950s, the term of inquiry has become a label for various unconventional teaching methods to promote curriculum movement. Thus, the inquiry concept can be bewildered if it is equated with some other approaches and it can be considered as an umbrella that comprises several teaching approaches (Prince & Felder, 2006). For instance, Bruner (1961) considered the discovery learning approach as a subset of inquiry approach when defining it as:

> Discovery learning is an inquiry-based approach in which students are given a question to answer, a problem to solve, or a set of observations to explain, and

> then work in a largely self-directed manner to complete their assigned tasks and draw appropriate inferences from the outcomes, “discovering” the desired factual and conceptual knowledge in the process. (p.132, cited in Prince & Felder, 2006)

Lee (2004) emphasises that inquiry is compatible with independent study, service learning, simulation, discussion, and interactive lecture. He argues that “probably the only strategy that is not consistent with inquiry-guided learning is the exclusive use of traditional lecturing” (p. 10). Newman Jr et al. (2004) further mention that different characteristics of IBL can match some other learning strategies such as discovery learning and open learning. For example, open learning seems like guided inquiry, which both of them require students to propose their questions or problems to investigate (Gordon & Brayshaw, 2008). Consequently, the involvement of students in investigating is a common characteristic between open learning and inquiry. Also, Swan, Pead, Doorman, and Mooldijk (2013) found that the confusion between IBL and discovery learning is one of the critical challenges of IBL implementation.

The distinction between IBL and some similar approaches is another challenge. One of these approaches is problem-based learning (PBL). Which may be defined as “an instructional learner-centred approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem” (Savery, 2015, p. 5). Spronken-Smith (2012) indicates that some researchers assume that there is an overlap between IBL and problem-based learning, but conceptual differences exist between these two approaches. For example, Prince and Felder (2006) indicate that the main distinction between PBL and IBL is that the kind of questions with PBL by definition including open-ended, ill-structured, and real world problem, whilst IBL might include these problems. However, this interpretation contrasts with various researchers who tend to distinguish between PBL and IBL in the type of questions which generally the answers for PBL questions already exist, while open-ended questions are often involved by IBL (Spronken-Smith, 2012).

The notion of collaboration is also used by Spronken-Smith et al. (2007) to distinguish. However, collaborative groups can be used in both IBL and PBL (Kahn & O'Rourke, 2004; Pawson et al., 2006). More recently, Savery (2015) distinguishes between these two approaches depends on the role of the teachers. He mentions that the teacher's role in IBL is a facilitator of learning and a provider of information, while in PBL teachers do not provide information regarding the problem assuming the students are responsible for that. However, Lee and Shea (2016) argue that IBL is more than just asking a question. Students should develop and answer their own questions (Lee & Shea, 2016). Thus, the distinction between IBL and PBL has been fraught with difficulty.

Some researchers who see IBL as an approach that comprises different methods assume that PBL as a subset of IBL. For example, Spronken-Smith et al. (2007, p. 3) suggest that PBL tends to be a form of IBL and consider it as a subset of IBL, with both being subsets of active learning (see figure 3.1).

Figure 3. 1. The relations between inquiry-based learning, problem-based learning, and active learning

Adopted from Spronken-Smith et al. (2007, p. 3)

3.5. The Beliefs of Teachers

There is a consensus in the literature about teachers' thinking that their intricate network of beliefs and understandings directly influences their instructional decisions (Bryan & Abell, 1999; Clandinin & Connelly, 1992; Crawford, 2007). Moreover, researchers indicate that the beliefs and understandings that teachers have about the local context may shape and alter curriculum reforms (Brickhouse & Bodner, 1992; Cronin-Jones, 1991; Keys & Bryan, 2001; Mansour, 2010; Wildy & Wallace, 1995). For example, Mansour (2010) found that teachers unlikely implement the curriculum reform if the curriculum developers fail to take into account teachers' knowledge and beliefs as well as the sociocultural factors that may impact or shape teachers' beliefs in planning and designing the new reform. The literature has further explained that teachers' beliefs may have impacts on the following: (i) their own knowledge acquisition and interpretation; (ii) task definition and selection; (iii) course content interpretation; and (iv) assessment methods (Clark, 1988; Mansour, 2010; Nespor, 1987; Pajares, 1992). This section will discuss the issues related to teachers' beliefs in education including the definition of teachers' beliefs, the relationship between teachers' beliefs and practice, and teachers' beliefs towards science education in general and IBL in particular.

3.5.1. Definition of "Teachers' Beliefs"

Although teachers' beliefs may be one of the most important factors in teaching, it is not always clear what teachers' beliefs mean. As noted by Pajares (1992), the matter of teachers' beliefs "does not lend itself to empirical investigations" (p. 308). He also highlighted how difficult it is to be scientifically methodical in the study of teacher beliefs, claiming that 'teacher beliefs' is a "messy construct" (p. 309), often without a precise definition and which:

> …travels in disguise and often under an alias of attitudes, values, judgements, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions, implicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principles, perspectives, repertories of understanding, and social strategy, to name but a few that can be found in the literature. (Pajares, 1992, p. 309)

Loucks-Horsley, Stiles, Mundry, Love, and Hewson (2009) differentiated between beliefs and opinions in the following way: “beliefs are more than opinions: they may be less than ideal truth, but we are committed to them” (p. 27). Also, Pajares (1992) remarked that the complexity associated with studying the beliefs of teachers has stemmed from poor conceptualisations, definitional issues, and different understandings of belief structures. Ultimately, ‘belief’ cannot be defined in a straightforward way (Cantu, 2001), but Pajares (1992) highlighted the importance of avoiding a situation wherein the study of educational beliefs becomes Nespor’s (1987) ‘entangled domain’. As Nespor (1987) stated:

> The concept of entangled domain has to do with instances or examples or entities which can be identified by some criteria as belonging to a given domain, but which at the same time do not all share some important sets of criteria and do not fall into relationships of dominance and subsumption with each other. Thematic features overlap only partially and incompletely across domains. (p. 325)

In spite of the fact that teachers’ beliefs are difficult to define, Pajares (1992) suggested that “all teachers hold beliefs, however defined and labeled, about their work, their students, their subject matter, and their roles and responsibilities ...” (p. 314). Since human beings hold beliefs about all things, Pajares (1992) proposed that researchers should distinguish between what teachers’ beliefs generally and in education particularly. Furthermore, he advised that the area of educational beliefs of teachers need to be clearly identified and specified by researchers. Examples of those areas including teachers’ beliefs towards teaching and learning; the nature of knowledge; self as a teacher; and so on. Based on Pajares recommendation, this study will focus on pedagogical beliefs of science teachers, specifically toward IBL. The following section will address the relationship between teachers' beliefs and practice.

3.5.2. The Relationship Between Teachers' Beliefs and Their Practice

Nespor (1987) argued that the beliefs teachers hold are heavily influenced by their own educational experiences, especially the formative experiences they themselves have had as students. The categories of belief systems teachers hold similarly might be influenced by their sociodemographic characteristics and other formative personal experiences. As documented by Helms (1998) and Knowles and Holt-Reynolds (1991), personal beliefs are potent in impacting on the approach to pedagogy that teachers take. Consequently, teachers draw on cohesive systems of belief, shaped by their experiences, which subsequently impact on the roles they adopt in professional life (Clark & Peterson, 1986; Shulman, 1986). Hence, although a broad degree of uniformity can be observed across teacher contexts, the curricula teachers are guided by, and the subject-specific knowledge they hold, pedagogical approaches are diverse. For instance, Yerrick, Parke, and Nugent (1997) highlighted that teachers who see knowledge as a set of factual statements tend to transmit a set of factual statements to students. Contrastingly, teachers who believe that students should interpret knowledge, their teaching practice often focuses on the process of knowledge transformation amongst learners (Yerrick et al., 1997).

3.5.3. Teachers' Beliefs Among Science Teachers

In terms of the core domains of teachers' beliefs highlighted in the literature as having the most consequential influence on classroom practice, Ernest (1989) defined these as beliefs about learning, teaching, and the nature of the subject. Among science teachers, the nature of the subject of which they are instructors is generally denoted their 'nature of science' beliefs, and the connection between nature of science beliefs and pedagogy has formed the basis of numerous research projects (Lederman, 1992, 1999; Lederman & Zeidler, 1987; Trumbull, Scarano, & Bonney, 2006). As detailed in Lederman (1999) and Lederman and Zeidler (1987), the relationship between the two variables can be observed in the classroom, but it might be not strictly linear because other determinants may have impacts on this relation.

Regarding the implementation of reform-based practices, a central factor that can impact the association between practice and beliefs is the interface between the suppositions lying at the centre of the reform. To be specific, Gregoire (2003) refers to these suppositions as specifying what scientific knowledge is and how it can best be transmitted. Since educational reform proceeds from the initial supposition that scientific knowledge is built from the ground up, it appears that teachers will approach classroom reforms more readily when their nature of science beliefs are compatible with those of the reform (Kang, Orgill, & Crippen, 2008; Kang & Wallace, 2005). More defiles in the two following paragraphs.

IBL is probably compromised when this compatibility is absent and teachers may not implement it (Roehrig & Kruse, 2005). Hence, when teachers' beliefs lack compatibility with those of the reform, conceptual transformation is sometimes warranted to facilitate the implementation of IBI. Nevertheless, the literature suggests that a teacher's belief change is a hit-and-miss prospect when the scheme of the reform conflicts with their underlying assumptions (Cross & Hong, 2009; Romanowski & Amatullah, 2014). Gregoire (2003) mentioned a set of common reactions to proposed reforms that involve neglect, minimal change, and denial, and while a superficial analysis of the change may yield favourable results, closer inspection indicates that IBI is not being effectively implemented.

In addition to the misalignment between teachers' suppositions about the nature of science knowledge and the reform agenda, lacking compatibility (and a subsequent belief change) can arise between a teacher's attitudes and beliefs towards teaching and learning and those proposed by reform mandates. As noted by Kagan (1992), beliefs towards teaching and learning centre around the teacher's perceptions regarding viable teaching strategies and assessment approaches. Here, it is notable that the curriculum reform's benchmarks and frameworks could mandate that teaching and assessment approaches are used which may be incompatible with science teachers' beliefs. Consequently, the beliefs themselves, reinforced over time through continuous application and identification, are challenged by the reorientation of the educational system towards inquiry-based teaching (Chinn & Brewer, 1993; Cross & Hong, 2009). In view of these considerations, it may explain why certain reform mandates fail to succeed in facilitating change at the classroom level.

3.5.4. Teachers’ Beliefs About Education Reform and IBL

Tobin, Tippins, and Gallard (1994) emphasised that since teachers’ beliefs constitute “a critical ingredient in the factors that determine what happens in a classroom” (p. 64), it may be significant to consider their beliefs towards education reforms implementation. The literature is decided regarding the idea that teachers’ beliefs prefigure change, thereby highlighting the criticality of the teacher as the facilitator of educational reform (Choi & Ramsey, 2009; Forbes & Davis, 2010). In the Rand Change Agent Study (1973-78), the importance of the teacher was further emphasised when it was observed that local factors were more consequential in facilitating change than federal programme guidelines (McLaughlin, 1990).

Hence, what motivates this study is the following consideration: namely, that when teacher’s beliefs about education reform, in the present study inquiry-based learning, are not considered, the reform mandate may be destined to encounter implacable difficulties (Ballone & Czerniak, 2001). Bybee (1993) mentioned in reflecting upon science education reform:

> I remain convinced that the decisive component in reforming science education is the classroom teacher. We certainly need books, reports, and recommendations for new policies, and we need new materials, projects, and programs. However, unless classroom teachers move beyond the status quo in science teaching, the reform will falter and eventually fail. (p. 144)

Ultimately, teachers' beliefs about IBL and their base of knowledge for implementing IBL may influence their practice (Anderson, 2002; Crawford, 2007; Hume & Coll, 2010; Keys & Bryan, 2001; Song & Looi, 2012; Xie & Sharif, 2014). This is further supported by the findings suggesting that teachers who believe in the effectiveness of IBL are characterised by a greater likelihood of promoting it in their professional life (Alhendal et al., 2016; Hutchins & Friedrichsen, 2012; Keys & Bryan, 2001; Wallace & Kang, 2004). In a comparable manner, Pajares (1992) identified a statistically significant relationship between the educational beliefs held by teachers and the practical aspects of their teaching, including lesson plans, pedagogical decision-making, and classroom manner. Furthermore, Smolleck and Yoder (2008) emphasised the direct connection between decision-making and systems of belief, thereby indicating that teachers' beliefs regarding the teaching of science as inquiry lie at the centre of reform. Moreover, when relevant beliefs are stronger, more positive, and characterised by a greater level of optimism, relevant reforms are likely associated with a higher level of success.

The literature has consistently borne out these considerations. For instance, Keys and Bryan (2001) detailed how teachers' beliefs regarding the implementation of IBL may significantly affect their practice and "teacher beliefs about students and learning, such as ability levels or the need for drill and practice, represent obstacles to inquiry-based instruction" (p. 635). In Crawford (2007), the researcher investigated the knowledge and beliefs of a sample group of five trainee teachers from a large secondary school in the Eastern United States with respect to the issue of teaching science using IBL. Interviews and classroom observations were the data source. The results indicated that the teachers' intention and capacity regarding the issue is directly related to the beliefs they hold about science teaching. Crawford (2007) further described how “it became apparent that beliefs about teaching science as inquiry played a critical part in decisions about planning instruction” (p. 635).

In Bundy (2004), the researcher detailed how the likelihood of behavioural change being facilitated is potentially dependent on the question of whether beliefs and feelings can change. This stems from the way in which behaviour represents a product of the relationship between beliefs and feelings. Hence, in the light of Choi and Ramsey’s (2009) finding that the implementation of IBL in classrooms has been relatively unsuccessful, the importance of teachers’ beliefs, attitudes, and knowledge is highlighted. Moreover, every science teacher in Wallace and Kang’s (2004) sample group was enthusiastic about the prospect of implementing IBL, and their beliefs about how scientific knowledge should be transmitted in classrooms were connected to their beliefs about the application of IBL. For instance, one teacher who considered that the ideal approach to science teaching involves the transmission of the principles of the scientific method broadly incorporated IBL into their pedagogy. The study of Wallace and Kang (2004) emphasises the importance of teachers’ beliefs in influencing their decisions and, by extension, their behaviour. The results, therefore, are consistent with Pajares (1992), who argued that beliefs and behaviours have an impact on lesson plans, classroom practices, and decision-making.

Anderson (2002) reported on further evidence to suggest that the absence of the requisite beliefs and experiences among science teachers may lead to a situation in which

IBL is unsuccessful. In a comparative study, Eick and Stewart (2010) concluded that teachers who engaged in reform-based approaches to science teaching were non-uniform regarding their understanding of the nature of science and, moreover, in the way that they implemented the curricula. This is consistent with the notion that the science teachers' endorsement of a framework of belief which is compatible with the objectives of IBL promotes favourable engagement with the practice (Blanchard, Southerland, & Granger, 2009; Crawford, 2007; Eick & Reed, 2002). Studies directed at high-school teachers found that the sample group's implementation of IBL was primarily driven by their experiences, beliefs (both personal and cultural), and the effective learning outcomes they had witnessed (Marlow & Stevens, 1999; Wallace & Kang, 2004). Nevertheless, it is important to recognise that while the preponderance of evidence suggests that teachers' beliefs determine the way in which IBL is implemented, the literature is still limited regarding precise data pertaining to the influencing factors which promote IBL in science classrooms (Minner et al., 2010).

To sum up, it is clear, from the mentioned literature, that teachers' beliefs are fundamental determinants of their likelihood of implementing curriculum reform and their utilisation of IBL. Furthermore, evidence suggests that teachers' cultural, personal, and learning experiences may dictate the nature of their beliefs about classroom practice. These findings are crucial because of the growing consensus that teachers' beliefs and capacities might constitute the hinge on which the success of educational reform and IBL turns (Capps & Crawford, 2013; Lumpe, Czerniak, Haney, & Beltyukova, 2012). In view of this, it may be necessary to gain comprehensive insight into science teachers' beliefs towards IBL, classroom practice, and the nature of scientific knowledge.

3.6. Teachers' Knowledge and Implementation of IBL

Despite previous studies into teachers' knowledge of IBL, it is apparent that there is more work to be done in this arena. According to DiBiase and McDonald (2015) and Keys and Bryan (2001), further research is needed into the issue of teachers' beliefs, knowledge, and practices towards IBL. A fundamental question of knowledge for the implementation of IBL is pedagogical and process-specific knowledge (Blanchard et al., 2009; Kennedy, 1998). When adequate insight has been established into the current state of teachers' knowledge about what IBL involves, precise measures of IBL implementation may be formulated. Ultimately, these may illuminate any incongruences between teachers' perceptions regarding their professional IBL practice and objective facts about their practice. The following sections will investigate the extant findings in the domain of teachers' knowledge and implementation of IBL.

3.6.1. Teachers' Knowledge of IBL

Science teachers might hold various ideas about IBL, as a result, they may struggle to build a common understanding of IBL and how it should be developed practically. Asay and Orgill (2010) found that teachers see IBL as a process more than a vehicle for learning science content. Previous experience could have an impact on teachers' understanding of IBL (Eick & Reed, 2002). In addition, Wang and Zhao (2016) emphasise that the understanding of IBL could be affected by the culture, thus its conception diverges between countries.

Another dilemma of IBL is that there is a lack of providing a full description of IBL in publications. This can be confirmed by Asay and Orgill (2010) study who analysed the articles published in The Science Teacher from 1998 to 2007 in order to come up with a conclusion of how IBL are practically practised in classrooms. They defined IBL practically by the essential features detailed in Inquiry and National Science Education (NRC, 2000). This study identified that only a few articles provide a full picture of IBL. They highlighted that gathering and analysing evidence were more frequently repeated than other features of inquiry which were reported in %25 of the articles. They concluded that there is a correlation between gathering and analysing evidence and teachers' view of inquiry as a process more than a vehicle for learning science content. Their findings also revealed that most inquiry activities were teachers-directed. Nevertheless, it might be worthy to indicate that the study of Asay and Orgill (2010) was based upon research carried out in the US context. Thus, the findings of their study may not be generalised to other contexts.

Wang and Zhao (2016) conducted a comparative study to investigate 90 high school science teachers' understandings of the nature of science (NOS) and IBL in Shanghai (China) and Chicago (USA). Using open-ended questionnaires and interviews, this study established that, in general, the level of American teachers' understandings of NOS and IBL is higher than Chinese teachers (Wang & Zhao, 2016). They also indicated that the differences in the understanding of NOS and IBL exist between science teachers in

Shanghai and Chicago (Wang & Zhao, 2016). They articulated that the positivism philosophy affects Chinese teachers' ideas, "who always regard scientific cognitive process as a copying process, and science is a real reflection of object" (p. 107). Furthermore, they found that many reasons such as little experience in doing inquiry and culture of Confucian (Chinese inherent cultural traditions) affected Chinese teachers' understanding of IBL and NOS. In contrast, science education in the USA has emphasised NOS and IBL for a long time, as a result, American teachers have a better understanding of its concepts (Wang & Zhao, 2016). The study of Wang and Zhao (2016) provides evidence that the conceptual and pedagogical views of IBL could be influenced by the culture.

The lack of compatibility between teachers' knowledge of IBL and the notion of inquiry set forth in reform agendas and, in particularly severe cases, the absence of teachers' knowledge in this regard, was documented in Brown, Abell, Demir, and Schmidt (2006); Capps et al. (2016); Demir and Abell (2010); Hong and Vargas (2016); Lotter, Harwood, and Bonner (2006); Romero-Ariza, Quesada, Abril, Sorensen, and Oliver (2020). Also, these studies have noted that many teachers hold ideas about IBL which are not necessarily included under the umbrella of IBL practices as discovery learning and hands-on work (refer to the definition of IBL section). Moreover, a consistent pattern in each of the aforementioned studies is one where teachers provide accounts of IBL which are incomplete; to be more specific, they mention pertinent inquiry-based activities, including questioning or independent investigation, while neglecting others, including data-oriented work or critical reasoning. For instance, a sample of four newly-qualified teachers was consulted in Demir and Abell (2010) with respect to the issue of how IBL can be defined. While the answers specified student-generated questions and data collection, they failed to mention a wider understanding of IBL in their description as evidence, explanation, communication, and justification of science concepts. Furthermore, they found that teachers may have confusion between the concept of IBL and some other teaching methods. For example, they mentioned that teachers viewed IBL as “(a) a process of problem-solving that relies on initiative of students; (b) guided inquiry that relies on teacher’s guidance; and (c) inquiry as discovery learning” (p. 730). Similar findings were reported by Brown et al. (2006), who examined 19 college-level science professors. Additionally, Ozel and Luft (2013) sought to gain insight into the same issue using a sample group of 44 newly-qualified secondary science teachers. Interviews revealed that teachers with relatively little experience described IBL by drawing on the activities of evidence-gathering and questioning, while other pertinent activities were not mentioned. Using a 20-participant sample of primary science teachers working in an urban Australian area, Ireland, Watters, Brownlee, and Lupton (2012) conducted interviews which revealed the following ideas held by teachers about IBL in science; (i) experience-centred activities, involving an emphasis on teachers’ provision of stimulating sensory experiences; (ii) problem-centred activities, where learners are presented with challenges; and (ii) question-centred activities, where teachers aim to encourage learners to formulate and address questions.

Drawing on a sample group of 26 science teachers for the fifth to the ninth grades, Capps and Crawford (2013) held interviews and gave written assignments to gain insight into their knowledge of IBL. For the most part, the teachers' responses linked IBL to discovery learning and practical work, while relatively few teachers drew a connection between IBL and activities centring on question-investigation, data usage, and evidence collection. Morrison (2013) reported that teachers collectively regarded IBL as 'finding things out', thereby leading them to encourage their learners to engage in exploration and experimentation. Nevertheless, the researcher emphasised that every teacher engaged in the project with a previous understanding of what was termed 'inquiry teaching'. Using a 34-participant sample group, Kang et al. (2008) asked teachers to categorise brief teaching situations as representative of IBL or not, and teacher-defined features of IBL were categorised as consistent or inconsistent with the essential features of IBL (NRC, 2000). Comparably, Kang et al. (2008) identified that of the five essential features, most teachers highlighted the use of scientific questions, the prioritisation of evidence, and the communication of explanations, while they neglected to mention less-pertinent features, including evaluation and the empirical grounding of these explanations. Similar findings were documented by Chabalengula and Mumba (2012). However, the study of Kang et al. (2008) also found that the length of experience of a teacher and their understanding of IBL may be related in a directly proportional way, where more of the essential features of inquiry would be included into the teachers' knowledge as their years of practice increased. More recently, Capps et al. (2016) examined a sample group of 149 K-12 science teachers, interviewing 11 to evaluate their knowledge of IBL. For the most part, the teachers failed to identify IBL enactment based on well-structured knowledge, and the interviews indicated that teachers mapped non-inquiry activities onto inquiry statements cited from reform documents. In view of this, the researchers concluded that teachers may encounter difficulties in interpreting and implementing IBL requirements for science education reform, thereby emphasising the need for assistance in differentiating between IBL activities and irrelevant activities. Like Capps et al. (2016) and Herrington, Yezierski, Luxford, and Luxford (2011) who investigated eight high school chemistry teachers' beliefs and knowledge about IBL, found that some teachers were unable to distinguish between inquiry and non-inquiry activities.

In a recent study, Romero-Ariza et al. (2020) surveyed and interviewed science teachers in England and Spain to investigate their views and their implementation of IBL. They surveyed 53 English science teachers and 76 Spanish science teachers. They also interviewed four English teachers and six Spanish teachers. The outcome of their study showed that teachers focused on hands-on activities while neglecting the cognitive and epistemic aspects of IBL. They also found that the participants in both countries held a positive attitude towards IBL based on their views that IBL has a positive impact on students' motivation and engagement in learning science. However, the study of Romero-Ariza et al. (2020) is small-scale research and involved a group of teachers who were already positively inclined towards IBL. Thus, their findings cannot be generalised to another group of science teachers globally or even in England and Spain.

The international literature pertaining to teachers' knowledge of IBL is extensive, but relatively few studies have focused on the Middle East. At the two ends of the spectrum, USA-based studies are the most prevalent, while not a single study has investigated the issue in the Kingdom of Saudi Arabia. This is particularly concerning because of the way in which experiences inform the nature of a teacher's understanding of IBL, thereby highlighting the context-dependent nature of the results (Demir & Abell, 2010). Furthermore, since the generalisability of any findings in this domain is limited, different findings may be yielded within Saudi Arabia. Ultimately, this stresses the potential need for in-depth, wide-ranging, and extensive research into this topic in the Saudi Arabian context, particularly, where the implementation of IBL is recent.

In terms of the limitations of the above studies, sample sizes tend to be small, and the breadth of the sampling frames seems insufficient (where relatively few studies investigated K-12 science teachers). A representative example of this is the study conducted by Capps and Crawford (2013), which used a 26-teacher sample group ranging from grade 5 to grade 9. Furthermore, in Morrison (2013) project, while several data collection instruments were employed, the 6-teachers sample group cannot be generalised to a wide population. Also, he only observed one lesson for each teacher.

Another limitation stems from the lack of data collection instruments used in the extant literature, where the research groups have typically drawn on no more than two. In Capps et al. (2016) recent study, the researchers used self-report data (from surveys) and interviews, and they did not involve themselves in the actual classroom. Correspondingly, Lotter et al. (2006) and Ozel and Luft (2013) used interviews and observation data without using a questionnaire. Other studies, including Brown et al. (2006) and Hong and Vargas (2016), restricted the dataset even further by drawing on only one data collection instrument (namely, interviews). The current study aims to use questionnaire, interviews, and classroom observation as a tool for data collection. In addition, it will involve science teachers from different school stages in Saudi Arabia. Thus, it may contribute to fill the gap in the literature and provide a further understanding of IBL.

3.6.2. Teachers' Implementation of IBL

The extant data pertaining to the frequency of teachers' implementation of IBL is highly variable between self-report and observation data, with the dominant feature being that self-report data suggest high frequency while observational data suggests low frequency. Marshall, Horton, Igo, and Switzer (2009) used a sample of 1,222 teachers in a sizeable school district in the South Eastern United States to measure several variables, including the reported use of IBL. One item in the survey instrument asked teachers to specify what percentage of their teaching time they devoted to IBL, with the average self-report result amounting to 38.7%. However, the reliability of this result is questionable for the reason that the interpretation of IBL activities was left to the participants (note the self-report status of the data). A comparable limitation is identifiable in Banilower, Heck, and Weiss (2007), who examined the self-report questionnaire data of 18,657 K-8 teachers who were engaged in a project of curriculum reform involving IBL. One of the numerous measurement objectives of the researchers was to examine the impact that professional development has on teachers' self-reported usage of "investigative teaching activities". The items of the questionnaire regarding "investigative teaching" asked the participant teachers about their practice of "working on models or simulations" and "hands-on activities". The fact that the researchers did not specify the overall frequency of investigative teaching use. Additionally, the teachers' responses themselves are unclear insofar as they could pertain either to the implementation of investigative teaching or merely the implementation of activities superficially associated with investigating teachings (for example, hands-on teaching). Similarly, Capps et al. (2016) surveyed 149 K-12 teachers to measure teachers' knowledge and implementation of IBL. They found that teachers reported high frequent use of IBL, but without "well-structured" knowledge.

It appears that access to valid self-reports from teachers regarding their knowledge and implementation of IBL would be invaluable in gaining insight into the current status of inquiry teaching. Nevertheless, Capps et al. (2016) highlighted that acquiring valid self-report data with respect to this issue is difficult owing to the subjective nature of the data; in turn, this stems from the lack of understanding among the teachers regarding the mainstream definition of IBL as stated in the curriculum reform, which consequently leads to an absence of standardisation. As previously noted, over-reporting may result when teachers regard non-inquiry practices as inquiry practices, and it possibly occurs as a result of acquiescence bias (motivated by the teachers' knowledge that inquiry activities are usually a sign of effective teaching (Messick and Jackson, 1961 cited in Capps et al., 2016) or it could be motivated by their knowledge that inquiry activities are expected to be doing). Imprecise measures of IBL implementation are also present in studies such as that of Banilower et al. (2007), who implemented a survey instrument which was overly broad to assess the issue and not specifically geared toward IBL implementation and, therefore, that may result in lack of precision findings.

Although self-report data regarding the implementation of IBL may not reflect the nature of the real situation, it still constitutes valuable data (Capps et al., 2016). This primarily stems from the possibility that the disparity between the self-report data and the observational data, for example, in Marshall et al. (2009), is indicative of teachers' misunderstanding of IBL. In other words, teachers may report that they implement IBL, but in actuality, they are not. Nevertheless, to confirm this, a devoted study may be required to verify (or elevate) the degree of teachers' implementation of IBL with using more focused instruments (Capps et al., 2016).

Observational data collected by researchers are generally more valid when comparatively examined against self-report data, but unfocused data collection instruments continually lead to interpretational difficulties. For example, in the large-scale research project of Weiss, Pasley, Smith, Banilower, and Heck (2003), it was found that 15% of K-5 science lessons centred on IBL, while fewer (2%) science lessons in grades 9 to 12 did. This finding appears to indicate a significantly reduced frequency of IBL implementation when compared to the self-report surveys. Yet, the lack of specificity of IBL aspects in the observation protocol compromises the validity. For instance, the observation protocol did not focus on IBL activities. It instead addressed more general teaching activities, including the degree to which "the design of the lesson incorporated tasks, roles, and interactions consistent with investigative mathematics/science" (Weiss et al., 2003, p. 132). In this study, it appears that little guidance was given to the observer about how to interpret IBL. Therefore, the findings tend to be more subjective.

Despite the potential presence of several limitations (primarily associated with interpretational factors) in the large-scale studies of Marshall et al. (2009) and Weiss et al. (2003), both research published broad data regarding IBL implementation. In contrast to Marshall et al. (2009), which based its suggestion that implementation frequency of IBL was high on self-report data, Weiss et al. (2003) conservatively provided a value based on observational data. Along with the numerous problematic aspects of self-report data already discussed, it is also important to recognise that teachers' self- report findings regarding implementation frequency of IBL are inconsistent with small-scale studies, which indicates that the implementation of IBL into classrooms may not occur very often. A representative example of this is Capps and Crawford (2013), which collected observational data from the lessons given by 26 teachers that the teachers themselves had specified as their best examples of IBL. The observations aimed to comparatively examine lesson features against the essential features of inquiry teaching (NRC, 2000), thereby resulting in the finding that almost all teachers implemented no IBL (a small number of 4 teachers implemented a high level of IBL aligned with NSES). In Ozel and Luft (2013), 44 newly-qualified teachers' lessons were compared against the essential features of inquiry teaching, with the researchers concluding relatively little congruence between the lesson features and the essential features of inquiry. For those teachers found to implement IBL, the most prominent features were conducting investigations and questioning.

Observational studies that compare teachers' implementation of IBL against the five essential features of inquiry as identified by NRC found that teachers' practice of IBL tends to be very structured or teacher-centred (Capps & Crawford, 2013; Cook, Walker, Weaver, & Sorge, 2015; Karaman, 2007; Leonard, Barnes-Johnson, Dantley, & Kimber, 2011). More importantly, these studies found that the majority of teachers were unable to demonstrate a robust ability to teach science as inquiry. Also, these studies found that some features of IBL were more prominent in the classroom than others. For example, Cook et al. (2015) who observed and interviewed five teachers in grades 3–6 found that the following inquiry features were more prominent in their observed lessons than the other inquiry features: 'learners are engaged by scientifically oriented questions'; 'teacher engages learners in planning investigation'; and 'teacher helps learners give priority to evidence'. However, Cook et al. (2015) found that teachers rarely implemented the inquiry feature of 'learners evaluate the explanations in light of alternative explanations'. Similar results were reported by Blanchard and Sampson (2017). In another study, Leonard et al. (2011) who investigated the implementation of IBL among 13 elementary preservice teachers found that the inquiry feature 'learners formulate conclusions and/or explanations from evidence' was the most observed feature in teachers' practice. In contrast, they found that inquiry feature 'learners are engaged by scientifically oriented questions' was the lowest observed inquiry feature in the classroom. So, these contrasting studies suggest that teachers' implementation of IBL is different based on the context of the research.

Leonard, Boakes, and Moore (2009) investigated eight elementary preservice teachers' implementation of IBL. They found that half of the participants exhibited student-centred practices while the other half engaged students in teacher-centred practices. They also found that the strongest inquiry feature in teachers' practice was 'learners give priority to evidence'. In contrast, teachers were weakest in the inquiry feature 'learners are engaged by scientifically oriented questions'. Furthermore, they concluded that teachers' content knowledge about IBL did not appear to be correlated with teachers' ability to engage students in IBL. Additionally, they found that teachers implement IBL in different ways. However, only one lesson per teacher was observed in the study of Leonard et al. (2009), so a complete picture of teachers' practice of IBL would not necessarily be provided.

To conclude this section, the literature identifies two important issues when discussing teachers' implementation of IBL. The first issue is that IBL is not frequently implemented in the classrooms (e.g., DiBiase & McDonald, 2015). The second issue is that teachers implement IBL in a way that is different than intended by the policy makers (e.g., Capps & Crawford, 2013). Teachers' beliefs and attitudes can cause such issues. In some situations, the attitudes of teachers that emerge from their beliefs, skills, and knowledge appear to be obstacles to IBL implementation. In other situations, teachers hold positive attitudes towards IBL but their knowledge about IBL appears to be inconsistent with the policy documents.

3.7. The Challenges of IBL Implementation

While IBL has been recommended in many national science curricula (e.g., Saudi Arabia and the US), its incorporation into practice is not an easy task to accomplish. The literature has highlighted several obstacles that may hinder the implementation of IBL in classrooms. For instance, research has indicated that classroom size, time, classroom management, availability of resources, teachers' preparation programs, students' assessments, lack of content and pedagogical knowledge, teaching beliefs, inadequate professional development and administrative support could serve as barriers to IBL enactment (Anderson, 2002; DiBiase & McDonald, 2015; Fitzgerald, Danaia, & McKinnon, 2019; Gillies & Nichols, 2015; Jones & Eick, 2007; Keys & Bryan, 2001; Kim, Tan, & Talaue, 2013; MASCIL, 2014; Ramnarain, 2016; Ramnarain & Hlatswayo, 2018; Roehrig & Luft, 2004; Zhang et al., 2005). Determination of the common obstacles to the use of IBL in science classrooms may be beneficial in order to promote IBL reform in Saudi Arabia. Thus, the primary aim of this section is to review the research into the challenges of IBL in science classrooms. By doing so, more discussion about the above-cited studies will be provided.

Crawford (2000) emphases that "teachers striving to change their pedagogy to include strategies that teach students about scientific inquiry through ill-structured projects may lack knowledge of the processes involved" (p. 933). She defines "ill-structured projects" as not following clear steps. Moreover, she suggests that it might be necessary for teachers to change their role in teaching science to be a guide, mentor, or collaborator in order to appropriately engage their students in IBL practice. Roehrig and Luft (2004) conducted a qualitative study to investigate the barriers to IBL implementation of 14 beginning secondary science teachers in the US. The main findings highlighted main factors that constrained their teachers' enactment of IBL as following: (1) the understanding of scientific inquiry and the nature of science, (2) teaching beliefs, (3) pedagogical and content knowledge, and (4) issues related to students and management. Similarly, Keys and Bryan (2001), in their review of literature, came to the conclusion that these factors can highly influence teachers' application of IBL.

Anderson (2002) provided a clear description when he classified the dilemmas and barriers to IBL implementation into three dimensions: cultural, political, and technical. He considers the cultural dimension to be the most important since it is related to beliefs and values such as views of textbook and assessment, and commitment to textbook and "coverage". The political dimension includes the lack of in-service professional training, insufficient resources, unresolved conflicts between teachers, etc. Finally, the technical dimension includes matters such as the inadequate competency of teachers, the challenges of adaptation to the new teachers and students' roles, difficulties of cooperative work and assessment, etc.

A study was carried out by Zhang et al. (2005) to find out the possibilities and obstacles of IBL in Chinese schools. Based on questionnaires and interview data, the authors concluded that in order to effectively implement IBL in schools, several matters need to be considered including (1) impartial distribution of resources in rural and urban schools, (2) large class size, (3) systemic change within teacher professional development, materials, curriculum plan, relevant resources, and (4) a rearrangement of students' examinations in the light of IBL goals. This result may highlight some of the major issues of IBL enactment in China. However, the reliability of the result may be influenced by a presentation about IBL that was delivered by an American researcher to the participants between the completion of the first and second questionnaire. In addition, the participants were selected from well-developed schools, therefore, more issues could be found if the study involved some underdeveloped areas in China.

Jones and Eick (2007) provided in-depth analysis, in their case study, of two middle school science teachers who started implementing an inquiry-oriented curriculum in Mallard city in the USA. The interviews and observational data of this study indicated that classroom management, material management, and students' assessment were the primary obstacles to the use of IBL. Jones and Eick (2007) claim that classroom management could be a significant issue when executing IBL for the reason that students may be unfamiliar with this kind of learning. However, they proposed that teachers' beliefs and professional development could play a critical role in overcoming the barriers to IBL implementation. This can be buttressed by Buczynski and Hansen (2010) who carried out a qualitative case study in the US to measure the impact of professional development programs on teachers' practices of IBL. Drawing on a sample of 118 grade 4-6 teachers, they substantiated the view that professional development programs could increase teachers' science content knowledge and as a result improve the enactment of IBL activities in the classrooms. They concluded that teachers' professional development can mitigate to a degree the obstacles of IBL.

Gillies and Nichols (2015) interviewed nine grade 6 teachers from five different schools in Australia to investigate their perceptions about IBL. The teachers involved in this study reflected a positive view toward IBL. However, the 6 teachers expressed many concerns when implementing IBL in classrooms such as lack of science content knowledge and pedagogical skills, availability of physical resources, and the time available to cover the demands of the curriculum and the requirements of the assessment. In the same country, Fitzgerald et al. (2019) identified the barriers to IBL implementation among 34 secondary school science teachers. The interview data revealed that time restrictions, lack of teachers' professional development, teachers' inadequacy of definitions and models of IBL, and the poverty of resources were the main barriers to IBL. It can be noted that the results of both studies are quite similar, although the research samples are different in terms of school level and size. Despite this, both studies did not provide information about how teachers use IBL in the classroom since classroom observation data was not obtained.

Kim et al. (2013) employed a qualitative study to explore the challenges of IBL practice in the new primary science curriculum in Singapore. Based on the analysis of written reflections of 41 teachers, the authors found that teachers may face many dilemmas in implementing IBL such as the readiness and abilities of students, curriculum's demands, insufficient classroom time, students' assessment, confusion on the meaning of inquiry, lack of content knowledge, and low community support. These obstacles also were found by DiBiase and McDonald (2015) who developed a survey to assess the perceptions of IBL among 275 middle and secondary science teachers from four schools in the USA.

Unlike DiBiase and McDonald (2015) and Kim et al. (2013), Ramnarain (2016) conducted mixed methods research to investigate the perceptions of science teachers about the challenges of using IBL in high schools in South Africa. An adapted version of the Science Curriculum Implementation Questionnaire (SCIQ) (Lewthwaite, 2001) was employed to collect quantitative data from 186 science teachers, while unstructured interviews of a subset of the survey sample were carried out to gather qualitative data. The study's outcomes revealed that teachers experience internal and external factors which serve as significant constraints on the enactment of IBL. Internal factors include lack of science and pedagogical content knowledge, curriculum knowledge, and students' knowledge. By contrast, external factors involve time, limited resources, professional support, and the school environment. Although Ramnarain (2016) study may provide useful data regarding the difficulties of IBL implementation in high school, particularly in the African context, it fails to consider the differences of teachers' views according to their specific disciplines. Additionally, classroom observation data might provide more insights about teachers' perspectives and school conditions if the author had included it.

In a recent study, Ramnarain and Hlatswayo (2018) explored the perceptions of IBL amongst grade 10 physical sciences teachers in South Africa. Analysis of 11 questionnaire responses and interviews revealed that some obstacles create tension in teachers' willingness to implement IBL such as large classes, the demand of the curriculum, teaching materials, and availability of laboratory facilities. However, this research is limited by the fact that it was restricted to a small sample from a rural district in South Africa. In addition, only physics teachers were involved.

A research project was carried out by MASCIL (2014) (funded by the European Union Seventh Framework Programme) to explore teachers' beliefs, views, and current practice of IBL in 13 European countries. The definition of IBL that was adapted by MASCIL (2014) is

> Inquiry-based learning aims to develop the inquiring minds and attitudes that are required to cope with an uncertain future. Fundamentally, IBL is based on students adopting an active, questioning approach. Students inquire and pose questions, explore and evaluate, and the problems they address are relevant to them. Learning is driven by open questions and multiple solution strategies. Teachers are proactive, supporting struggling students and extending those that are succeeding through the use of carefully chosen strategic questions. They value students' contributions, including their mistakes, and scaffold learning using students' reasoning and experience. In the classroom there is a shared sense of purpose and ownership. (p. 7)

The study's findings were based upon a large-scale survey of 1132 mathematics and science teachers. The outcomes of the survey revealed that system restrictions, resources, and classroom management issues influenced the use of IBL in the classroom. What is interesting about this data is that system restrictions issues, such as insufficient time, the school system, and students' assessments, have the greatest impact on the implementation of IBL. In contrast, most other studies have found internal issues are the most important (Anderson, 2002; Barron & Darling-Hammond, 2010; Capps & Crawford, 2013; Gillies & Nichols, 2015; Roehrig & Luft, 2004; Tosa, 2011).

MASCIL (2014) also found that teachers who reported fewer classroom management issues are more willing to implement IBL. Furthermore, this study demonstrated that the application of IBL in classrooms tends to be different by countries and school systems. Despite this, the findings of the study revealed that the presence of IBL in teaching practice seems to be unnoticeable in all countries investigated. One potential problem is that the scope of this research may be too broad, thereby providing in-depth data might be difficult. Therefore, the authors of this project proposed that further detailed research is needed to develop a deeper understanding of differences in IBL practice among countries. Another potential limitation of this project is that the contexts of the participants' schools were not explicitly described.

Tosa (2011) also demonstrated that the implementation of IBL significantly depends on the context. Tosa (2011) did a cross-cultural comparison study to explore middle schools' science teachers' attitudes and understanding about IBL between the US and Japan. She employed a survey instrument to measure teachers' attitudes about IBL from 191 participants. In contrast, interviews and classroom observations were used to investigate teachers' understanding of IBL. 9 American science teachers and 15 Japanese science teachers participated in the interviews and the classroom observations stages. The study's outcomes showed that teachers are supportive of the idea of IBL. However, they have different interpretations of IBL. Besides, the observation data indicated that little IBL takes place in classrooms in both countries for various reasons. For instance, she found that the lack of science content may hinder American teachers from implementing IBL, while Japanese teachers seem to be unprepared to support their students in order to construct their own understanding of scientific concepts. Notwithstanding the relatively limited sample, Tosa's (2011) study may provide evidence that the issues of understanding and implementation of IBL are not identical across countries. Therefore, it may be predicted that IBL problems would also have varieties among developing countries such as Saudi Arabia. Moreover, the generalisation of findings from one country to another is problematic.

Considering all of this evidence, it seems that the constraints of IBL implementation could be divided into two groups:

1- Internal factors such as lack of content and pedagogical knowledge and skills, and teachers' beliefs.
2- External factors such as time, resources, class size, lack of professional development and preparation programs.

However, there are some issues that are more often reported by researchers which may prevent science teachers from the implementation of an inquiry-oriented curriculum. For instance, numerous researchers have demonstrated that teachers who have little knowledge about IBL and science content are unlikely to implement inquiry-oriented curriculum reform (Crawford, 2000; Gillies & Nichols, 2015; Kim et al., 2013; Luvanga & Mkimbili, 2020; Ramnarain, 2016; Roehrig & Luft, 2004; Tosa, 2011). Therefore, in order to put IBL into practice effectively, teachers may require holding a high level of pedagogical skills and science content knowledge (Crawford, 2000; Davis, Petish, & Smithey, 2006; Keys & Bryan, 2001).

The lack of teachers' preparation and professional development programs could lead to a lower response to inquiry-oriented reform (Dai, Gerbino, & Daley, 2011; Fitzgerald et al., 2019; Gutierez, 2015; Ramnarain, 2016). Researchers have shown that professional development intervention could influence teachers' beliefs and practice of IBL (Harris & Rooks, 2010; Lotter, Yow, & Peters, 2014; Lotter et al., 2018; Tseng, Tuan, & Chin, 2013;

Yager & Akcay, 2010). For example, Tseng et al. (2013) found that teachers who implement more IBL in classrooms have had a positive experience towards IBL in professional development programs. Therefore, they highly recommend that IBL experience should be deemed when developing training programs for science teachers. Similarly, Johnson (2006) highlights that in order for teachers to be capable to practice IBL in science classrooms, it is essential for them to be involved in a training program that provides opportunities for teachers to practise such a teaching approach. Furthermore, Lotter et al. (2018) investigated the impact of one-year professional development program on 102 middle school science teachers' beliefs and implementation of IBL as well as self-efficacy to practice IBL in the USA. The findings of this study revealed that the professional development program could help to increase teachers' efficacy of IBL and the quality of implementing it.

Another major concern of IBL implementation emerging from the literature is that classroom management. According to Davis (2006), classroom management issues may lead to less engagement in teachers towards inquiry-oriented reform. Many researchers have maintained that IBL practice can be problematic in terms of classroom management and teachers may experience difficulties in controlling students when executing IBL (Davis et al., 2006; Jones & Eick, 2007; MASCIL, 2014; Roehrig & Luft, 2004; Romero-Ariza et al., 2020). Also, Hayes (2002) mentions that teachers may not implement IBL because they might have concerns about relinquishing their authority to control and guide students. Harris and Rooks (2010) claim that the change in the way that teachers manage their classrooms is necessary to effectively apply IBL. They propose that IBL requires various types of classroom management approaches that consider the interrelated relationship between instruction and management. Moreover, large classroom size may lead to difficulties for teachers to manage and guide students throughout IBL activities (DiBiase & McDonald, 2015; Kim et al., 2013; Ramnarain & Hlatswayo, 2018; Zhang et al., 2005). So, IBL may not be workable in such circumstances. Time restraints have been also identified by literature as barriers to IBL implementation (Dai et al., 2011; Dobber, Zwart, Tanis, & van Oers, 2017; Fitzgerald et al., 2019; Gillies & Nichols, 2015; Gutierez, 2015; Kim et al., 2013; Long & Bae, 2018; MASCIL, 2014; Ramnarain, 2016; Romero-Ariza et al., 2020). Gutierez (2015) emphasises that teachers may not implement IBL reform because it requires much time to prepare, manage, and evaluate. In the study of Kim, Hannafin, and Bryan (2007), teachers indicated that the class period is insufficient to develop and apply IBL. In addition, researchers (DiBiase & McDonald, 2015; Kim et al., 2013; Ramnarain & Hlatswayo, 2018) have reported that the heavy content of the curriculum that teachers require to cover may minimise the use of IBL. Therefore, the performance of teachers might be influenced by a high teaching load and a shortage of time.

The literature informs us that the requirements of student assessment could affect teachers' practice of IBL (Gillies & Nichols, 2015; Jones & Eick, 2007; Kim et al., 2013; Long & Bae, 2018; MASCIL, 2014; Zhang et al., 2005). For example, based on a survey of 582 science teachers, Dai et al. (2011) found that the examination-driven system in China is a major barrier to IBL implementation. Likewise, Gutierez (2015) highlights that the assessment of students in the Philippines focuses on content learning more than learning through IBL. Therefore, teachers tend to pay close attention to the content and the amount of students' knowledge of science concepts rather than a deep understanding of these concepts (Gutierez, 2015). Gutierez (2015) further argues that even though teachers are willing to include more IBL activities in classrooms, they might not be able to eliminate the traditional method of teaching since a high volume of the topics needs to be addressed. Moreover, if assessments are standardised between each grade, teachers typically devote more time to prepare students for tests (Gutierez, 2015). Consequently, students' assessments may need to be designed in a manner that is compatible with IBL.

Many researchers concur that lack of resources serves as an obstacle to IBL (e.g., Fitzgerald et al., 2019; Gillies & Nichols, 2015; Long & Bae, 2018; Luvanga & Mkimbili, 2020; MASCIL, 2014; Ramnarain, 2016; Ramnarain & Hlatswayo, 2018; Romero-Ariza et al., 2020; Zhang et al., 2005). For instance, Gejda and LaRocco (2006) found that 77.2% of the participants in their survey indicated that resources were a critical factor in determining the use of IBL. Gejda and LaRocco (2006) study involved 820 secondary science teachers from Connecticut state in the USA. They argue that in order for teachers to change their practice to IBL, sufficient resources should be allocated. This finding is also supported by Herrington et al. (2011) who found that substantial changes to teachers' practice of IBL occurred after providing quality resources. Therefore, the availability of resources might be necessary to increase the possibility of IBL practice.

To date, however, relatively few studies have investigated the obstacles of IBL in the Middle East. While different issues regarding IBL implementation may be found in every specific context, it is possible that above-mentioned results might not be applicable to the Saudi context. Furthermore, these studies tend to address the challenges of IBL in their countries. Nevertheless, these studies may provide a conceptual and theoretical framework for research in the field in the Middle Eastern countries. In the case of Saudi Arabia, science education' curriculum and pedagogy are influenced by practice, policy, and research conducted in developed countries (particularly the US).

Another weakness of the above literature is that most studies fail to distinguish between teachers' perspectives about IBL according to their specific discipline (e.g., physics, chemistry, and biology), gender, teaching school level (primary, middle, and high). According to Breslyn and McGinnis (2012), the implementation of IBL has been widely investigated in the absence of comparison between the differences of disciplines such as physics and biology. They confirmed that science teachers may have differences in the conception and implementation of IBL based on their specialisation. Consequently, to fill this gap in the literature, more research is required to find out the differences among science teachers according to their specific disciplines, gender, and school level of teaching.

3.8. Educational Change

As the present study is related to implementing a new reform in Saudi Arabia, it is worth discussing matters related to educational change and the most important factors that might affect teacher change. Thus, this section discusses the definition of educational change, the process of implementing a change, and the key factors and circumstances that may influence the implementation of educational reform.

3.8.1. Definition of Educational Change

Educational change or innovation is a type of 'change' and it can be defined "as a deliberate, novel, specific change, which is thought to be more efficacious in accomplishing the goals of a system" (Miles, 1964, p. 14). According to Marsh (2009), "innovation is the planned application of ends or means, new or different from those which exist currently in classroom, school or system, and intended to improve effectiveness for the stakeholders" (p. 114). Changes in education, regardless of how they are evaluated, take place in an evolving and complex setting, with a range of variables at play over a protracted period of time (Fullan, 2007). Challenges to implementation arise from the fact that educational change is not a linear and unitary phenomenon, but rather a "multidimensional" one (Fullan, 2007). Fullan (2007, p. 30) reports that three dimensions should be considered when implementing a new policy or programme in education:

1. The possible use of new or revised materials (instructional resources such as curriculum materials or technologies).

2. The possible use of new teaching approaches (i.e., new teaching strategies or activities).
3. The possible alteration of beliefs (e.g., pedagogical assumptions and theories underlying particular new policies or programs) (p. 30).

Fullan (2007) argues that “change has to occur in practice along the three dimensions in order for it to have a chance of affecting the outcome” (p. 31). So, an educational reform may fail in achieving its objectives if these three dimensions are not given full attention (Fullan, 2007). For example, teachers may use new curriculum materials, but their teaching strategies remain the same. In another example, teachers may use new materials and change some teaching styles. However, their beliefs are inconsistent with the assumptions underlying the change, which could have a negative impact on the success of the innovation (Fullan, 2007).

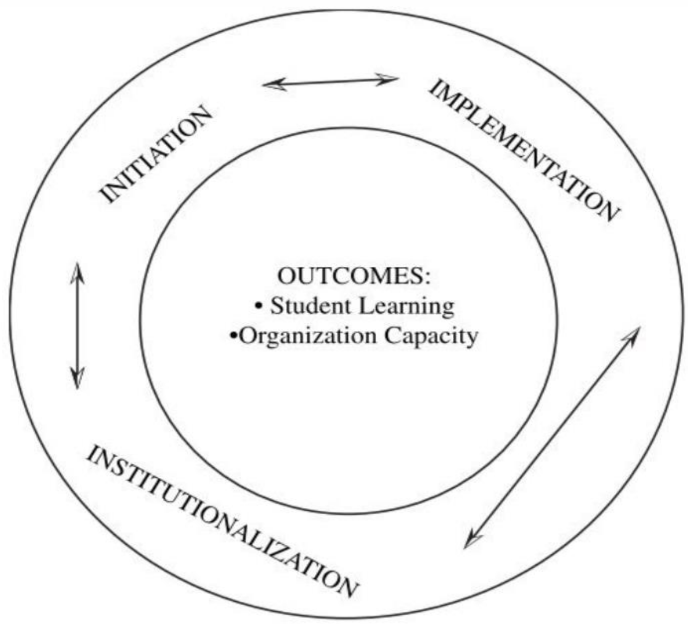
Fullan (2007) states that “educational change is technically simple and socially complex” (p. 84). A vast range of obstacles and hurdles present themselves during educational change processes, not least those pertaining to planning and coordination. Fullan’s (2007) notion of implementation conceives of it as the processes involved in realising a normative ideal in practical terms, rolling out a programme and/or a series of activities or governance mechanisms, with social agents for whom the practices are new. Teachers are central to this process; they are core agents of change and curricular modification.

The nature of educational change is one of varying binaries – for example between changes that are imposed top-down and those that are partaken in by willing agents at the base; between changes that are pre-planned in great detail and those that are generated and applied through an organic and evolving process of iteration and deliberation; and between changes established as standardised norms to be consistently applied and those that are intended to be pragmatically implemented in response to the needs and dynamics of specific contexts (Fullan, 2007). Regardless of the motivations behind the reforms and policy makers, transcending both individual practitioners and institutions, and regardless of the imperative of change, all genuine educational changes comprise salient personal and collective encounters with an experience that is uncertain and unstable (Fullan, 2007). When such change is successfully practised and embedded, individuals and their institutional backdrops become characterised by high skill acquisition, a sense of achievement and ample professional development (Fullan, 2007).

3.8.2. Implementation and the Change Process

A single version of how to undertake educational change is lacking, but scholarship to date nevertheless commonly agrees that the process can be divided into discreet, chronological phases. This, to a certain extent, simplifies the conceptualisation, as there is in actual fact a myriad range of actors, settings, and institutions at play. The dividing lines between each of these are blurred, with causal interactions being multipolar (Wedell, 2009). A simple conception of educational change sees the process as being comprised of (i) initiation, (ii) implementation and (iii) institutionalisation (Fullan, 2007). Figure 3.2 below shows the three phases of the change process.

Figure 3. 2. Phases of the change process



Adopted from Fullan (2007, p. 66)

The 'initiation' stage here consists of proactive plans being made to launch or adapt to a particular innovation (Fullan, 2007). The 'implementation' stage forms the major focal point of the present study. This stage requires iterative planning and decisions being put into tangible practices (Hayes, 2018), and it requires the actors who are in need of change or expecting change to be introduced to new activities, structures, ideas or programmes (Fullan, 2007). The 'institutionalisation' stage involves the innovation or change being embedded into the 'living' system that has been developed (Fullan, 2007). The overall process is, naturally, more complex than this simplified model suggests, with Fullan (2007) referring to it as a 'snarled process' (p. 67). The chronology of the process is not straight forwards either, because decisions and actions taken at various stages can often reformulate or delete decisions and actions taken formerly, so the process is in fact a dynamic and evolving one (Fullan, 2007). To execute a straight forward and coherent process of change requires every obstacle to progress being dealt with adequately as they arise (Cheung & Wong, 2012). The implementation stage is the one that encounters the most risks and the most obstacles to effectiveness (Fullan, 2007). From this point, it becomes clear whether the change becomes embedded into the new institutional system or whether it is discarded or suffers from neglect.

The allegory of the bridge is useful in comprehending the complicated, multivariable nature of the implementation phase. A physical bridge must be developed and constructed using a range of stakeholders and professionals (Hall & Hord, 2020). Any efforts to circumnavigate the process and cheat by missing out a key aspect will mean the bridge will not be stable (Hall & Hord, 2020). Effective implementation thus requires a continuous and iterative process of dialogue, experiment and validation (Wedell, 2009). This overall procedure consists of phases that are varying in their pace, and each component of the process will vary in the extent to which it accords with official plans (Wedell, 2009). The notion of implementation as a hierarchically organised change initiated and managed by the top tier is a notion that fails to recognise this nature of the implementation phase (Hopkins, Ainscow, & West, 1994). Change is hereby seen as being a non-negotiated process of automatic implementation, or as a single "event". This notion fails to factor in that the proposed objectives of a change differ significantly from the practical process of change on the ground – i.e., in schools, local organisations, and educational authorities. The next section discusses some key factors that could affect the implementation of a change.

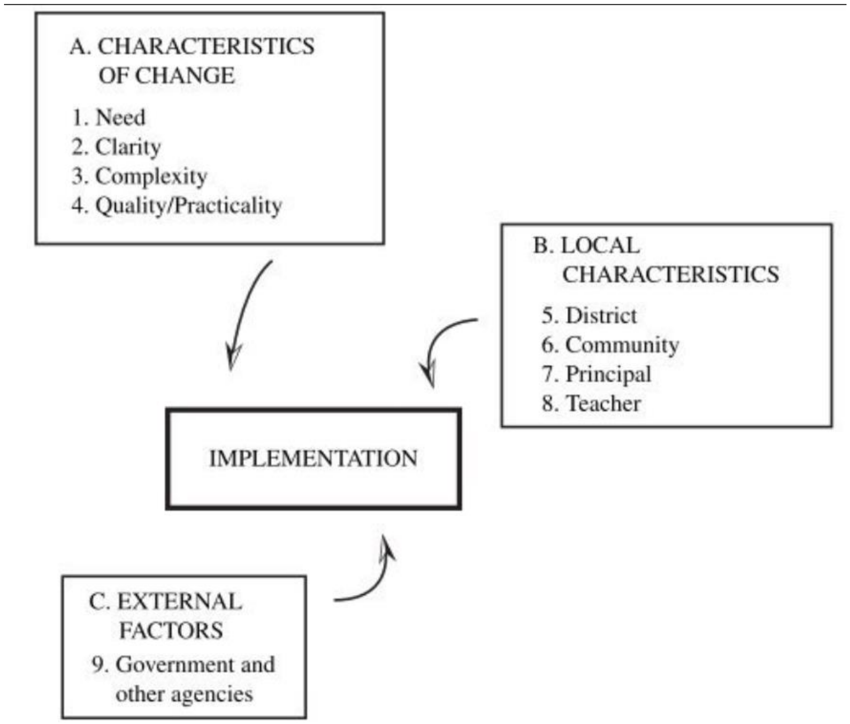
3.8.3. Factors Impacting the Implementation of Educational Reform

The reform and revision of curricula encounter crucial obstacles to effectiveness (Fullan, 2007). Many high-level policy officials or abstract curricular planners posit that revising curricula is simple and linear in nature, but practice contradicts this position (Orafi & Borg, 2009). The reality in classrooms, for example, is that practitioners tend to implement formalised curricular reforms in ways that are congruent with their idiosyncratic values, preferred teaching methods and past professional experiences (Johnson, Freemyer, & Fitzmaurice, 2019). This discrepancy comprises both a barrier and an enabler of successful curricular reform implementation (Cuban, 1993). A range of important factors will affect how teachers apply and operationalise the formal intentions of policy officials. Fullan (2007, p. 87) lists nine key factors that influence the implementation process, grouped into three categories:

1. Factors related to characteristics of change, including need, clarity, complexity and, quality/practicality;
2. Factors linked to the local characteristics, including district, community, principal and, teacher; and
3. External factors influencing the implementation, including government and other agencies.

Figure 3.3 below shows the interactive relationship between these factors.

Figure 3. 3. Interactive factors affecting implementation



Adopted from Fullan (2007, p. 87)

These factors operate in a complex and interactive way, making it difficult to distinguish between factors according to their determinative weight (Fullan, 2007). They can constitute critical barriers to effectiveness.

Several of these factors are discussed by Fullan (2007). Fullan (2007) highlights that all components of the overall educational system must be utilised in the implementation of new curricula. Some of the major affective factors that impact on IBL in science curricula in Saudi schools comprise valuable examples. Saudi teachers, in implementing IBL curricular modes of teaching and learning, flag up the fact that, as raised by Fullan (2007), the factors that affect their work are varied and interact with each other. Fullan (2007) highlights that all stakeholder organisations and agents included within the overall system must be engaged in order for change to be effective. In Saudi Arabia, as elsewhere, macro-level reforms have failed to be effectively implemented because the change planning has not considered local cultural values and norms (Alghamdi, 2019). Key culturally specific institutions and individuals include the school and students, as well as teachers, school authorities and governors, parents, and other agencies. Fullan (2007) reminds us that change will be effective and well-managed when all these stakeholders are included, informed, and engaged in the process.

Teacher work conditions are central to successful change and reform (Fullan, 2007). The demands placed on teachers when changes are being implemented are often excessive, and teachers are required to change their practical work as well as their value systems, with coherent planning for how to affect these changes often absent (Kennedy & Kennedy, 1996). By encouraging close collaboration across and between curricular planners, teachers, researchers and governance bodies, teachers can be utilised as critical resources for effective change (Guskey, 2002). Continuing professional development courses for teachers are an important tool in this collaborative process. The proceeding sub-section explores critical factors that affect change implementation, with the focus being placed on factors that are especially pertinent to the present study.

3.8.3.1. Factors Related to Characteristics of Change

Change in education can be explored according to four major aspects: (i) needs, (ii) clarity, (iii) complexity, (iv) quality and practicality (Fullan, 2007). These are discussed in more detail below.

3.8.3.1.1. Needs

Change proposals can be impaired when there is inadequate conception of how the changes respond to primary and important needs (Fullan, 2007). It is vital that the needs which the change is intended to respond to are carefully considered and that the changes are directly targeted to address them (Fullan, 2007). A societal or school-specific need or set of needs must be conceived of clearly for change to be desirable and practicable (Jennings, 2012). The relative prioritisation of some needs over others is required, so the establishment of important needs is complex (Fullan, 2007). Needs will necessarily intersect and at times new needs will emerge during the actual implementation stage (Fullan, 2007). In terms of buy-in, teachers will engage with change more proactively when they believe the needs being addressed are pressing and relevant, and they will also engage better when they consider the change to have been properly researched and to be of direct benefit to the students whom they work with (Kennedy & Kennedy, 1996; Terhart, 2013).

3.8.3.1.2. Clarity

It is also vital that planners and policy designers fully conceptualise what they seek to achieve by implementing change, and that they are also clear as to precisely how they will affect change (Fullan, 2007). Clarity is essential. A degree of 'false clarity' can occur when change objectives and methods are inadequately mapped out in unsuitably simplistic ways (Fullan, 2007). This can result in ineffective implementation. Fullan (2007) argues that having incoherent or over-complex objectives, or having vague plans as to methods of effecting change, can hinder implementation from start to end. This is in great measure due to the fact that teachers struggle to conceive of the change and its necessity when change plans, objectives and means are not mapped out. A lack of clarity from curricular designers can in fact prompt growing anxiety and stress among teachers (Fullan, 2007). Teachers need to be provided with a coherent understanding of the theory that subtends the change and the practical, applied ramifications the change has for their work (Carless, 1998; Park & Sung, 2013; Spillane, 1999). Achieving this clarity among the teachers is challenging, because the technical language of policy and the presence of large-scale and grandiose objective statements can make the theoretical components hard to relate to practice (Schweisfurth, 2011). Teacher miscomprehension and/or incomprehension of curricular reforms are arguably the most critical barriers to effective implementation (Fullan, 2007). In an empirical study, Song (2015) identified that when teachers did not comprehend the goals and plans of the reforms clearly, this limited their engagement with the reforms and produced negative impressions of them.

3.8.3.1.3. Complexity

This refers to the degree to which implementers perceive the proposed changes to be complicated and convoluted (Fullan, 2007). This perception can comprise a key obstacle to implementation (Rogers, 2003), and it can especially arise when the changes teachers are asked to initiate are complicated and/or multiple (Brindley & Hood, 1990). Complexity can nevertheless also generate more widespread change because complexity by nature implies that the reform is systematic (Fullan, 2007). To ensure that complexity is a driver of change rather than an obstacle, policy makers need to undertake adequate consideration of the local, contextual norms and practices of the schools and teachers implementing the change (Wedell, 2009). Chan (2002) provides an example of ineffective change emerging from excessive complexity in an empirical investigation of task-based learning reforms in Hong Kong, whereby the teachers found it hard to comprehend the structural backdrop of the changes and the theories resting behind them. The teachers studied began to resort to their old teaching methods because they comprehended the reforms as incongruent with the specific contexts of their classrooms (Chan, 2002).

3.8.3.1.4. Quality and Practicality

These factors pertain to teacher perceptions of the value and importance of the changes, as well as the tangible availability of necessary resources for implementing the changes (Fullan, 2007). Often policy makers focused more on rapid adoption of changes can fail to prepare the required resources needed for teachers to successfully implement the changes. The period of time between the policy design process and the initiation of the changes in the classroom is held by teachers to be too short, and in cases in which schools are inadequately funded or teachers are inadequately trained, this can create stress, burnout and ineffectiveness (Day & Qing, 2009; Goodson, Moore, & Hargreaves, 2006).

'Practicality' specifically refers to the extent to which teacher skills and knowledge bases are sufficiently matched to the change being implemented. 'Practical' does not here mean 'easy' (Fullan, 2007), because it depends on existing support measures and the right learning and teaching environment being in place, not on teachers simply adapting to the change with ease.

3.8.3.2. Professional Development and Formal Training

Curricular changes demand that the teachers learn about and employ new skills, and they also demand that teachers challenge and modify their values, perceptions and idiosyncratic ideas about teaching and learning (Harris, 2003). Continuing professional development and training are thus crucial elements of an effective implementation of reforms. In the absence of development courses that engage teachers in new ways of conceiving and practising teaching, teachers often disengage from the process of personal change – even in cases where initial interest and engagement had been strong (Carless, 1998). A strong, clearly designed and skills-focused skills development programme must, therefore, be generated for teachers in order for change to be successfully implemented (Maaß & Artigue, 2013).

Nevertheless, numerous researchers (e.g., Darling-Hammond, Hyler, & Gardner, 2017; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Faraclas, 2018) argue that rapidly run, quick-fire workshops for teacher training are not sufficient for exacting lasting and salient changes. Conventional practices often involve episodic training that lacks rigour and is not systematic in its design and strategy (Darling-Hammond et al., 2017). For such training to be most effective, the programme must be taught over a long-term period, with a range of modes of engagement so that teachers can learn about new conceptualisations of learning and types of teaching (Darling-Hammond et al., 2017). The OECD (2005) claims that this training must be continuing, and that it must consist of practical experimentation and peer and student feedback, not solely formal teaching. One important practice is to engage the trainees in learning processes that mimic the ones they will deploy themselves in the classroom (OECD, 2005).

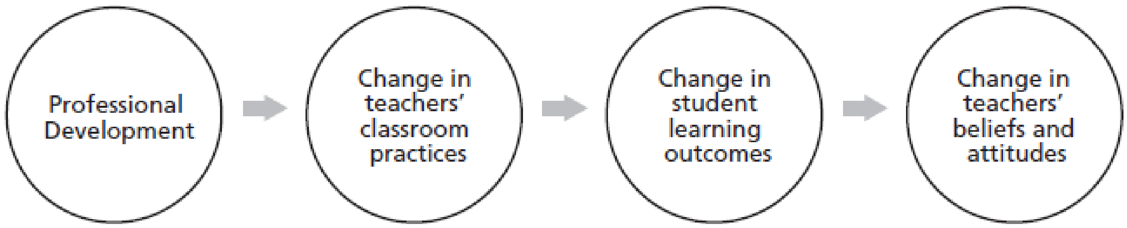
Longer periods of training have been found to have improved effects on teacher trainee learning – in particular because these tend to necessarily involve engagement with ideas in practice (Darling-Hammond et al., 2009). A range of empirical and experimental investigations of continuing professionals skills training aimed at teachers has found that when training involves practical application of skills in teaching environments, this is likely to produce improved learning outcomes for both teachers and pupils (e.g., Gerard, Varma, Corliss, & Linn, 2011; Johnson & Fargo, 2014; Maaß & Artigue, 2013; Supovitz & Turner, 2000; Weiss & Pasley, 2006). Furthermore, empirical studies that aimed to investigate the impact of professional development training on teachers practice of IBL identified that by undertaking comprehensive training the teachers were able to shift perceptions, assume positive attitudes to changes and apply IBL more effectively (Blanchard & Sampson, 2017; Capps & Crawford, 2013; Hofer & Lembens, 2019; Powell-Moman & Brown-Schild, 2011; Supovitz, Mayer, & Kahle, 2000).

Conventional modes of didactic training for teachers (e.g., lectures) have been found to often be less effective in embedding change (Darling-Hammond et al., 2017). This is in significant measure due to the fact that in such cases the teachers are passive, unengaged and perceive the trainers as having little salience to their specific working contexts (Darling-Hammond et al., 2017). Training must also directly discuss and problem-solve key barriers to implementation that teachers will face, because if it does not then teachers have little by way of resources for confronting such challenges (Shamim, 1996). Trainees must be vividly engaged in discussion of overt and covert obstacles to implementation in the classroom (Shamim, 1996). By doing so, teachers will collectively generate ideas for dealing with such issues and obstacles in the classroom (Shamim, 1996).

Adequate training programmes must consist of theoretical constructs and practical, applied behaviours, all the time enabling teachers to deliberate over the proposed changes and discuss amongst themselves how they can be implemented (Wedell, 2009). Achieving this harmony between theory and practice is essential. Formal training must also be complemented by peer support and systems of feedback and dialogue such as mentoring (Wedell, 2009). By embedding the formal content of training in the ongoing work of the classroom in practice, teachers can engage in comparative analyses of the core concepts and ideals presented and the practical issues, benefits and challenges that they encounter in applying these (Wedell, 2009).

As noted by Guskey (2002), continuing professional skills training often presumes that the process of professional and personal change within the teacher is simple and straight forward, whereas in reality this process is complex and encounters many hurdles. Guskey (2002) posits a model of teacher change (see figure 3.4) that factors in the myriad range of classroom experiences, normative and ideational changes and student learning experiences that influence the internal change in the teacher undertaking change. He notes that when teachers can visibly identify that the changes are having a tangible impact on student experiences and learning, they come to integrate and embed the change in their own belief systems far more effectively.

Figure 3. 4. A model of teacher change.



Adopted from Guskey (2002, p. 383)

Guskey (2002) posits the following three maxims as essential to effective training: (i) *Change is gradual and challenging*: teacher resistance to practical pedagogical change is commonplace, as with other professional groups, and acquiring new skills as well as applying them effectively demands lengthy periods of experiment and trial and error. (ii) *Receiving regular feedback on student progress is vital*: when practices are seen as observably effective, this elicits more engagement and improved perception of those practices. For teachers, knowing that they are having a positive impact on student learning is integral to adopting a change in the foreseeable future (see also Huberman, 1992). (iii) *Training must include continued, long-term support*: Training programmes must comprise of formal training but also ongoing feedback, briefing, support and learning mechanisms. Because it tends to be when teachers observe tangible impacts of the change on student learning, it is essential that training must be added to by systems of support and feedback whereby teachers can articulate the improvements they have seen. By ensuring such systems are in place, teachers will be more likely to adapt and continue to practise the changes (Loucks-Horsley et al., 2009).

Overall, the evidence is clear that teachers must partake in meaningful and structured training and skills programmes in order for them to apply and embed the changes in their classrooms. Implementation does not occur properly if teacher perceptual and normative changes do not take place. Training is to be seen as an ongoing, 'living' process whereby skills acquisition and knowledge, as well as practice and feedback, evolve and accumulate over time (Carless, 1998; Guskey, 2002). Changes to curricula and changes to modes of teaching and learning involve a vast range of variables and influences, and they exact a significant effect on teachers' lives, belief systems and experiences. As noted by Lamie (2005), to facilitate a smoother-running process of change, a positive, constructive and dialogical training environment must be created for the teachers, whereby the change is a process rather than a singular event. Clear and coherent objectives must be established, adequate resources must be available, ongoing support systems must be put in place, evaluative mechanisms and feedback loops must be generated, and teachers must be able to expand their awareness in order for the change to be made salient and effective for them as professionals (Lamie, 2005).

3.8.3.3. Teacher-Related Factors

Teachers are the major agents of effective educational changes. Effective and meaningful change depends mostly on teacher cognition, teacher perception, and teacher behaviour (Fullan, 2007). Teachers comprise the most important enablers or disablers of reforms and changes. This section discusses the effect of teachers' attitudes and understandings of the reform.

3.8.3.3.1 Teachers' Attitudes

As per the bulk of literature pertaining to educational change implementation, teacher attitudes are arguably the most vital factor in determining success or failure (Carless, 1998; Kennedy & Kennedy, 1996; Lamie, 2005; Mowlaie & Rahimi, 2010). This refers to how teachers evaluate the changes and how they emotionally engage with them (Van Veen & Sleegers, 2006). Teacher attitudes can create an operationalised gap between their stated ambitions and their classroom practices (Mowlaie & Rahimi, 2010). An exploration of the effects and role of attitudes on educational change and teacher experiences of change proceeds from here.

Teacher actions in the classroom are closely connected to teacher attitudes (Kennedy & Kennedy, 1996). The 'theory of planned behaviour' Ajzen (1991) posits that attitudes form clarified intentions and that these then inform behaviours, yet it factors in another two vital components: (i) subjective norms and (ii) perceived behavioural control. The first of these pertains to how teachers perceive other people (colleagues, students etc) to value a given behaviour. The second component pertains to the extent to which the teachers perceive themselves as having agency in certain circumstances. Behavioural control is in turn intersected with by teacher evaluations of their own skills and capabilities, because these factors are seen as determining the extent to which the teacher can affect meaningful, impactive changes. Teacher attitudes as determinants of change therefore rely pre-hoc on a sense of control over the situation and a belief that teachers possess the personal and professional resources needed to implement a desired change. Organisational support of teachers is thus vital for change to be effected, because teacher attitudes and agency are influenced in part by access to external support resources. Kennedy and Kennedy (1996) has found that positive teacher attitudes regarding change have to be complemented with subjective normative appraisals and perceived behavioural control that are conducive to adaptation and integration, and when these are absent teachers often resort to their older modes of teaching and learning. Placing excessive focus on just one of these elements of teacher attitudes can hinder the process of understanding what influences teachers in implementing change (Kennedy & Kennedy, 1996). In addition, teacher attitudes must be explored and analysed as they interrelate with the full range of additional drivers/disablers of change, because attitudes are formed, challenged and entrenched by factors such as school culture, organisational support, personality traits and colleague culture. A holistic perspective must be assumed that sees teacher attitudes as porously influenced by social norms, perceived behavioural control, and a vast number of other contextually specific factors.

3.8.3.3.1. Teachers' Understandings

Teachers experiencing and executing change must possess a clear knowledge base pertaining to the theory and applied practice of the reforms (Cohen, 1990; Spillane, 1999). A case study conducted by Wilson (1990) found that when a teacher had an inadequate comprehension of the theoretical grounding of the change at hand, and when they could not link that theory to applied pedagogy, the teacher dramatically struggled to implement the change. Inadequate comprehension of the change, its theoretical grounding and its practical ramifications also intersects with the variable of perceived uncertainty, as well as with the extent to which teachers are receptive to change (Waugh & Godfrey, 1993).

Teachers often miscomprehend certain elements of the change, including its overall purpose and its composite practices (Fullan, 2007), simply because the information is new. Spillane (1999) found that a sample of mathematics teachers being studied was ready to ostensibly adhere to curricular guidance, but when changes were introduced, they tended to see them as irrelevant to the practical nature of their classroom teaching. Miscomprehension can interplay with negative attitudes at times (Karavas-Doukas, 1995), with inadequate understanding of the change exacerbating negative perceptions and vice versa.

As flagged up by Cohen (1990), teachers often interpret and assimilate to curricular changes by looking through the prism of the older curricula. When modifications or dramatic changes are made, teachers often use their knowledge and experience of the former curriculum to navigate and comprehend the new policies and their inherent new norms and values. This indicates that when initiating training and skills development programmes geared to suit the changes being made, teacher comprehensions – from theory across to application – need to be heavily engaged with. Understanding how the teachers think and what their knowledge to date is, as well as conceiving of how to integrate new knowledge into teachers' schemata, are as important as conceptualising the change itself.

3.8.4. Conclusion of Educational Change Section

This section discussed key factors that may influence the effectiveness of educational change initiatives. The literature summarised above suggests that a range of factors might be pertinent to the context of the present study as this research is related to implementing a new reform in science education in Saudi Arabia. For example, teachers' understandings and beliefs about the rationale of the change, the clarity and practicality of the change, and the nature of professional development programmes could influence the effective implementation of the new reform in Saudi Arabia. The next chapter explains the research design.

Chapter 4: Research Design

4.1. Introduction

The main aim of this study is to explore Saudi science teachers' perceptions about IBL. In order to investigate the research objective, a mix methods approach was adopted with a variety of data collection methods: interviews, observations, and an online questionnaire were used. This chapter endeavours to explain the research paradigm, research methodology, data collection methods and the rationale for the approach taken. The study sampling and setting are also described. In addition, this chapter includes data analysis techniques and ethical considerations.

4.2. Research Paradigm

The research paradigm refers to the set of beliefs and assumptions about how problems should be addressed and understood (Kuhn, 2012). There are two main research paradigms, namely positivism and interpretivism. The positivist paradigm assumes that "all genuine knowledge is based on sense experience and can only be advanced by means of observation and experiments" (Cohen et al., 2007, p. 9). So, from a positivist point of view, theories and laws can be objectively described and empirically tested.

On the other hand, the interpretivist paradigm assumes that "the social world can be understood only from the standpoint of the individuals who are part of the ongoing action being investigated" (Cohen et al., 2007, p. 19). So, reality can be constructed and explored through human interactions, and the social world cannot be directly studied as individuals construe it in various manners. In addition, interpretivism suggests that there are multiple realities because people interpret and perceive events, situations, and contexts differently (Cohen et al., 2007). It attempts to make sense of the phenomena being investigated from subjective experiences of individuals. Reality, therefore, is complex and multifaceted (Creswell, 2014).

An interpretivist paradigm was adopted as the philosophical underpinning for the present study. This paradigm was utilised in this study because its aim was to explore Saudi science teachers' perspectives and implementations of IBL. Thus, the present study requires understanding and interpretation of how science teachers perceive and implement IBL via interaction with them in their natural setting. So, the researcher was able to generate meanings and themes from participants' experiences and to explore unexpected issues. Although participants' words and actions in the study are judged against a defined standard for IBL (the NRC (2000) definition), there is scope for interpretation in making these judgements, and this is superimposed on a background of the NRC (2000) definition being itself open to challenge and interpretation. The next section discusses the research methodology of the present study.

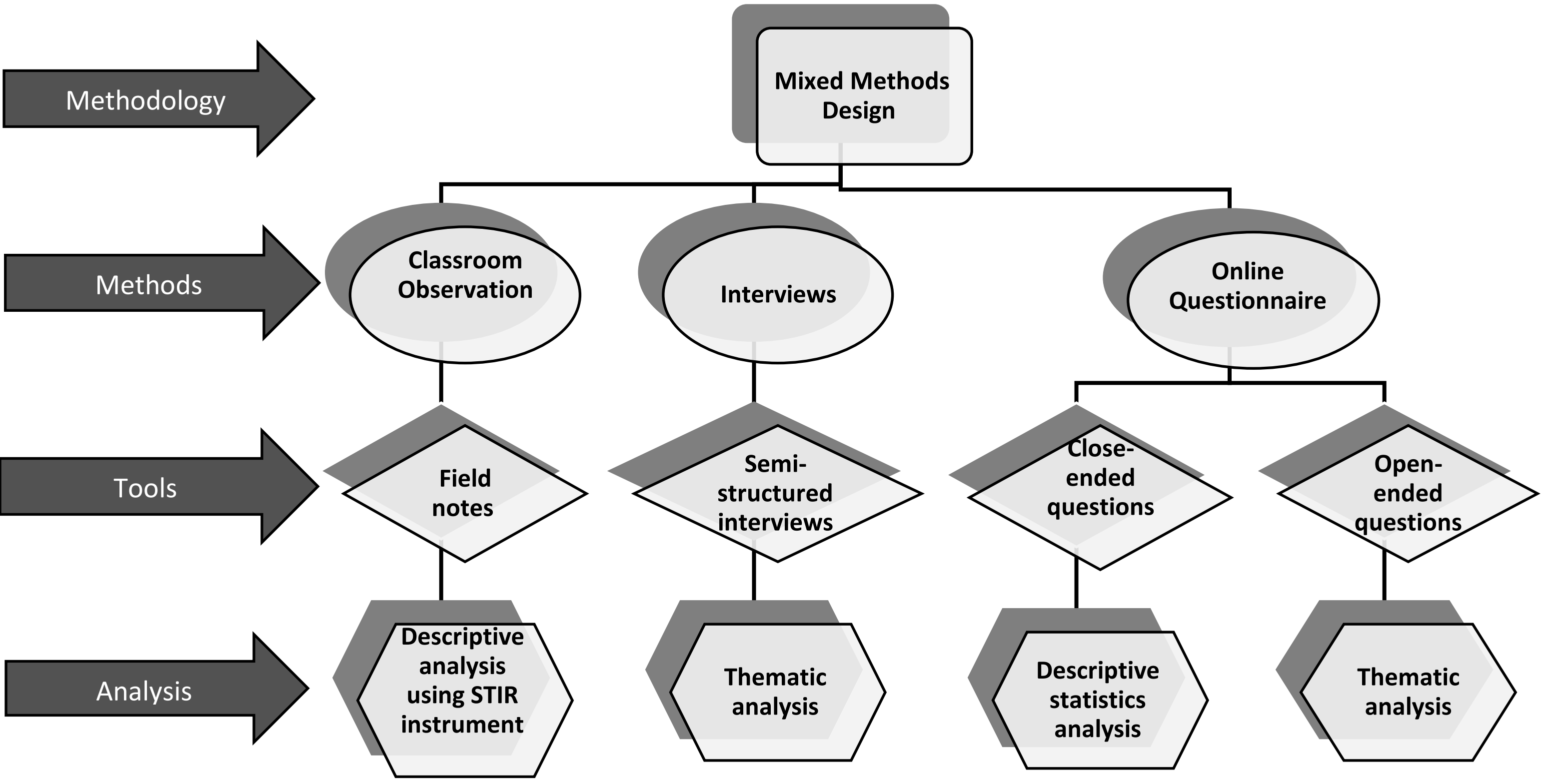
4.3. Research Methodology

Based on the nature of this study and the objectives involved, a mixed methods design was used. According to Creswell (2012), "mixed methods research has become popular […] in research methods and in approaches to 'mixing' quantitative and qualitative research" (p.534). Particularly, this method is suited to this study as it provided an interpretive capability which enabled the researcher to study the objectives involved in more depth and detail. The advantage of a mixed methods approach is that a combination of approaches can offer a balance strength, instead of adopting or focusing on a single approach (Cohen, Manion, & Morrison, 2007). Gall, Borg, and Gall (2006) argue that quantitative and qualitative research can enhance one another. For instance, the former plays a role in exploring, while the latter can confirm its discoveries. Another reason for using this approach is that the mixed methods approach can strengthen the validity and reliability of the result because more comprehensive data can be gathered from different resources (Abowitz & Toole, 2009). The other advantage of using the mixed methods approach is that it allows data to be compared, which could yield interesting results (Creswell, 2012). Furthermore, Yin (2009) argues that the mixed methods approach plays a significant role in exploring a phenomenon especially if the boundaries between phenomena, such as in this study (the perception of inquiry-based learning), and context (Saudi science teachers), are not clearly evident. Therefore, using a single approach for the current study may provide insufficient data to answer the research questions.

One of the advantages of using a quantitative approach for this study is that it allows obtaining data from a large number of science teachers in Saudi Arabia. As Bell (2014) and Denscombe (2010) state, a quantitative approach has the ability to gather responses from a relatively large sample, so the findings have the potential to be generalised. On the other hand, the adoption of a quantitative approach alone may not provide in-depth and detailed information (Denscombe, 2010). Therefore, using a mixed methods approach in this study might minimise this shortfall and many sources of data, such as semi-structured interviews, could be employed.

This research study was designed to use a mixed methods design comprising quantitative and qualitative approaches. The quantitative data was obtained through the questionnaire and classroom observation schedule. The survey questionnaire was designed to measure the level of agreement/disagreement amongst science teachers with regards to statements about teachers' knowledge. Also, there were some open questions in the questionnaire to gather qualitative data. The classroom observations allowed teachers' conduct in the classroom setting to be studied in the context of teachers' perspectives, how they impact on teaching practice, and how the teaching environment impacts on the association between teachers' perspectives and practice. The interview sessions were designed to gather qualitative data, thus, more in-depth insight into the teachers' perspectives can be explored. The following figure illustrates the research process.

Figure 4. 1. An illustration of the research process



4.4. Data Collection Methods

Kumar (2014) explains that researchers must consider factors such as their own experience along with budgetary limitations, the required sample size, the duration of the study, the resources available, and the research questions and purpose, when selecting data collection methods. According to Johnson and Turner (2003), the use of multiple data collection methods can be beneficial in cases where numerous sources of information are available, since this allows researchers to maximise the insights gained during the conduction of the study.

Three types of data collection methods were used for this study (observation, interview, and online questionnaire) in order to answer the research questions. The triangulation of data collection methods would provide a more coherent and complete picture of events than using a single method (Yin, 2009). The first stage of collecting data was classroom observations; and then the second stage was semi-structured interviews with the same teachers observed in the first stage. The third stage was an online questionnaire over a wider range of Saudi science teachers. In this sequence, it was possible to consolidate and verify the perception versus the reality in the classroom. Table 4.1 summarises the relationship between the research questions and data collection methods. The following sections provide details of each stage.

Table 4. 1. The relationship between research aims, questions, and data collection methods

Research Questions	Data collection methods
1- How do Saudi science teachers understand inquiry-based learning?	Interview & Online questionnaire
2- What are Saudi science teachers' beliefs about inquiry-based learning?	Interview & Online questionnaire
3- How do Saudi science teachers implement inquiry-based learning in the classroom?	Classroom observation, Interview & Online questionnaire
4- What are Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?	Interview & Online questionnaire

4.4.1. Classroom Observations

In the first stage, classroom observations were employed in order to study how science teachers implement IBL in the classroom as expected by the Saudi MOE. Also, classroom observations helped to consolidate the perceptions of the science teachers. A total of 45 science lessons were observed at different levels of schooling. The classroom observation data were useful to address the third research question (how do science teachers implement inquiry-based learning in the classroom?). Many studies (Brown et al., 2006; Capps & Crawford, 2013; Demir & Abell, 2010; Morrison, 2013; Ozel & Luft, 2013) have used classroom observations to investigate how science teachers implement IBL.

According to Denscombe (2010),

> Observation offers the social researcher a distinct way of collecting data. It does not rely on what people say they do, or what they say they think. It is more direct than that. Instead, it draws on the direct evidence of the eye to witness events at first hand. It is based on the premise that, for certain purposes, it is best to observe what actually happens. (p. 196)

So, by employing observation as a method of collecting data, the researcher has the opportunity to investigate the situation as it occurs. The main aim of conducting classroom observations for this study was to allow the researcher to find out how science teachers implement IBL in a natural setting. Furthermore, it provided the ability to collect data that clarify or support the information gained from the interviews and questionnaires.

The observation method may offer a number of benefits, with Denscombe (2010) noting that observations allow researchers to use simple instruments to gain highly valid and reliable data directly from participants. Another benefit is that researchers can examine participants' behaviour in the natural environment and make instant interpretations and observations that participants may otherwise be unable to express (Creswell, 2012). Cohen et al. (2007) highlight that the observation method is not predetermined, nor theory-driven; it is based on live situations and data. Therefore, it provides the benefit of obtaining information from real-world events and interactions that are occurring in front of the researcher at the time of the observation.

However, observation also has a number of limitations, including restrictions to observation locations and difficulties in building rapport and trust with participants depending on whether participants are used to be observed for the purposes of investigative study (Creswell, 2012). Participants may react in a different way because of the researcher's presence in the classroom (Denscombe, 2010; McKechnie, 2008). However, to overcome this issue, most teachers were observed more than once in the present study. Johnson and Turner (2003) and McKechnie (2008) suggest that the issue of changing participants' behaviour when they are observed decreases as time passes because it is difficult for participants to react unnaturally for a long time. Also, the researcher conducted observations before interviews in order to minimise the issue of changing teaching behaviour after verbal statements. Another limitation of observation is that analysis of observation data may take considerable time and effort (Cohen et al., 2007), but this issue was minimised by using an observation checklist in the present study.

The two main forms of observation are participant and non-participant observation (Creswell, 2012). In the case of participant observation, the researcher is able to directly engage in situations and events that occur in the research environment, whilst in the case of non-participant observation, the researcher maintains an interpersonal distance and observes as an onlooker only (Creswell, 2012; Yin, 2009). The non-participant form of observation is selected for the purposes of the current research, with the researcher performing a classroom observation from the back of the room, without engaging directly in the class activities, in order to ascertain how science teachers practise IBL.

The “Science Teacher Inquiry Rubric (STIR)” was adopted to measure teachers’ practice of IBL. The STIR instrument was developed by Bodzin and Beerer (2003) as an observational measure for classroom inquiry based on the National Science Education Standards’ essential features of inquiry instruction (NRC, 2000). Bodzin and Beerer (2003) indicate that the STIR instrument produced perfect inter-rater reliability (r=1) to be considered as a validated observation tool for IBL. Because the adopted science textbooks in Saudi Arabia are based on the NRC’s (2000) guidance, the STIR instrument as an observational tool was suitable to measure teachers’ practice of IBL in the present study. The STIR rubric assesses the use of the essential features of classroom inquiry and their variation. The STIR rubric examined if the inquiries were more teacher-directed, student self-directed or somewhere in between. The STIR instrument evaluates six categories based upon the essential features of classroom inquiry defined by the NRC (2000). The six categories are:

1. Teacher provides an opportunity for learners to engage with a scientifically oriented question.
2. Teacher engages learners in planning investigations to gather evidence in response to questions.
3. Teacher helps learners give priority to evidence which allows them to draw conclusions and/ or develop and evaluate explanations that address scientifically oriented questions.
4. Learners formulate conclusions and/or explanations from evidence to address scientifically oriented questions.
5. Learners evaluate their conclusions and/or explanations in light of alternative conclusions/ explanations, particularly those reflecting scientific understanding.
6. Learners communicate and justify their proposed conclusions and/or explanations. (Bodzin & Beerer, 2003, pp. 43-44)

Each category of STIR instrument contains five sub-measures aligned with the NRC (2000) definition of the essential features of classroom inquiry. Each category is ranked on a scale of 0-4 with 0 meaning the inquiry feature was not present and 4 being the highest form of inquiry strategies are being used (see appendix A.1 for STIR instrument).

4.4.2. Interviews

The second stage was semi-structured interviews with the aim of collecting data for all research questions and further enhancing the data collected from the classroom observations and the online questionnaire. The interview method has been extensively used by researchers to explore science teachers' perception of IBL, e.g., Brown et al. (2006); Capps et al. (2016); Demir and Abell (2010); Hong and Vargas (2016); Ireland et al. (2012); Ozel and Luft (2013).

The interview method is highly recommended in cases where the aim is to explore participants' experiences, emotions and perspectives, with greater depth of information required (Denscombe, 2010). Denscombe (2010) further states that the interview method poses numerous benefits, primarily including their ability to generate detailed information, their simplicity in terms of administration, their flexibility and capacity for alteration, their ability to offer a good response rate due to convenience for interviewees, and high validity due to the ability to evaluate the accuracy of interviewees' responses. Before interview sessions are conducted, researchers are required to obtain consent from participants whilst also ensuring that the sample population can be accessed within the planned time and budget (typically meaning that the sample should be selected from a single location or region) (Denscombe, 2010).

The use of the interview method in the current study allowed for greater insight to be gained into the perspectives of the science teachers involved in this research compared to the use of stand-alone questionnaires. The interviews provided the opportunity for interviewees to expand upon their answers based on the researcher's probing and encouragement. Interviews also allowed for greater rapport to be built, which facilitated greater understanding with regards to teachers' interpretation of IBL. Therefore, it was logical to perform the interview sessions after completing the observations with the same participants.

Interviews are typically structured, semi-structured, or non-directive, and maybe one-to-one, or carried out in the form of focus groups (Cohen et al., 2007; Denscombe, 2010). The interview format that was adopted in the current study was the semi-structured one-to-one interview type. The interview questions were developed based on the research questions and the existing literature (e.g., Lee & Shea, 2016; Morrison, 2013; Weiland, 2014) (see appendix B.2 for interview protocol).

Semi-structured interviews offer a number of benefits including the ability for researchers to focus on the most relevant questions whilst also remaining open to themes and avenues that may not have previously been considered by the researcher. The semi-structured interview approach, therefore, allows for a certain degree of flexibility and openness, with Newby (2014) noting that the method provides a good balance in the form of greater expressiveness combined with a predetermined structure and foundation for inquiry. The interview questions were designed based on the existing literature and the present research questions and aims. Also, the data collected from the classroom observations were useful to highlight main issues that need more explanation in the interviews.

As Hesse-Biber and Leavy (2010) explain, the main limitations of the interview method include the time required to conduct face-to-face interviews and the difficulty involved in ensuring that only the most relevant questions are asked so that the most appropriate and useful responses can be obtained for later analysis. Additionally, since face-to-face interviews may require the researcher to travel quite a distance or overcome a number of practical challenges or obstacles in order to meet with interviewees, this can also mean that the interview method is inherently demanding in terms of time resources (Denscombe, 2010). However, 27 teachers were interviewed in the present study.

4.4.3. Online Questionnaire

In the third stage, an online questionnaire was designed to collect data for all the research questions. Both quantitative and qualitative data were gathered from the online questionnaire. The online questionnaire was adopted for the current study because it was advantageous in offering access to a large number of participants in a short space of time. Furthermore, it allowed the study to determine the proportion of common ideas or perceptions held by the target teacher population and how these opinions are associated with some variables, such as gender, the stage of school, scientific domain, and teaching experience.

It is recommended in the literature that questionnaires are created with specific consideration of the data that needs to be gathered for analysis, with questions targeted towards a specific population (Denscombe, 2010). The questionnaire should also be designed with the research topic in mind and should be capable of obtaining accurate information from participants with regards to the research questions (Denscombe, 2010).

Questionnaires typically offer numerous benefits whilst also demonstrating a number of restrictions (Rea & Parker, 2014). One of the main advantages of the questionnaire method is its capacity to provide researchers with a large amount of data conveniently, in a short space of time, and at little cost. Using the questionnaire method, researchers can pinpoint respondents' perspectives on specific topics related to the research object, thereby ensuring a high degree of relevance (Denscombe, 2010). Denscombe (2010) also points out that questionnaires can be distributed to a high number of respondents at the same time frame. In this way, questionnaires are a cost-effective, and often completely costless, way of gaining information quickly (Bell, 2014). Additionally, questionnaires allow for complete anonymity and confidentiality whilst also enabling researchers to achieve high reliability based on the fact that a large number of respondents are asked identical questions (McMillan & Schumacher, 2010).

The questionnaire in the current study was designed based on the research problem and aims, as per the recommendations from the literature (i.e., Gall et al., 2006). Once the research problem and aims have been identified, the questions must be tailored specifically towards the target population (Slavin, 1991). Slavin (1991) also highlights the importance of maintaining focus on the research topic and avoiding bias, and also notes that shorter questionnaires can provide just as much insight as longer questionnaires if the questionnaire items are chosen carefully.

This being said, the literature highlights numerous limitations involved in the questionnaire method, such as the risk of a low response rate if the researcher fails to capture participants' interest (Gillham, 2000). Additionally, researchers should consider the literacy and fluency of respondents and ensure that the questionnaire items are clear and easy to understand (Gillham, 2000).

The aforementioned advantages and limitations of the questionnaire method were taken into account when designing the questionnaire used in the current study, and all of the questionnaires were administered on a self-completion basis. The questionnaire items were presented in such a way that they were uncomplicated and easy for respondents to understand, and full instructions were provided on how to complete the questionnaire.

As explained in the literature, questionnaires can contain numerous types of questions (Cohen et al., 2007), with the main types being fixed/closed, open-ended, or a combination of both (Kumar, 2014). Fixed/closed questions are typically answered with multiple choice or ranked responses, whilst open-ended questions allow respondents the freedom of entering a response of their choice. The combined approach allows for both types of answer. The main advantage of open-ended questions is that they offer greater depth and insight whilst also minimising researcher bias (Peterson, 2000).

The questionnaire in the current study contains both closed- and open-ended questions. A five-point Likert scale was employed in the case of closed-ended questions. The primary advantage of the Likert-type scale is that it allows researchers to measure the level of agreement (or disagreement) amongst participants. This may offer greater insight than simple yes/no responses. Oppenheim (2000) also asserts that Likert-type scales offer greater reliability than alternatives such as the Thurstone scale. Additionally, it has been suggested that since it is not possible to directly measure participants' beliefs, perspectives and attitudes as underlying variables, multi-item scales are more useful than single-item scales in this context (Ajzen, 2002). This being said, a number of limitations have been noted. The main limitation is that respondents can be prone to providing neutral answers when five-point scales are provided (Chimi & Russell, 2009; Dalal, Carter, & Lake, 2014). Another key limitation is that it can be challenging to focus on a specific response from a participant based on the overall score achieved (Chimi & Russell, 2009).

A five-point Likert scale type was adopted for the closed-ended questions because it contains a mid-point option which could be used to avoid forcing participants to choose a direction (Croasmun & Ostrom, 2011; Johns, 2010; Tsang, 2012). Also, numerous researchers (Johns, 2010; Krosnick & Presser, 2010; Lam, Allen, & Green, 2010; Nadler, Weston, & Voyles, 2015) stress that the absence of a mid-point option may increase the error in the questionnaire data because participants who have insufficient knowledge on a subject may commit to a certain position. Therefore, a mid-point option may reduce the chance of response bias (Croasmun & Ostrom, 2011). One of the limitations of a mid-point option is that the participants may misinterpret mid-option opinions. However, this issue could be minimised by clearly defining the midpoints meaning (Subedi, 2016; Tsang, 2012). Since the questionnaire for this study was related to teachers' knowledge and belief about IBL, it was necessary to include a mid-point option. Therefore, the mid-point was used for the questionnaire giving the option of 'neither agree nor disagree' in between 'agree' and 'disagree' in the five-point Likert scale.

A few open-ended questions were included to allow respondents to express their perspectives more freely and without being influenced by the researcher (Reja, Manfreda, Hlebec, & Vehovar, 2003). Also, it helped to explore any unexpected issues arising from teachers that might not be mentioned in the questionnaire items. Besides, the inclusion of open-ended questions allowed us to access respondents' perspectives and experiences in greater depth, which would not have been possible if only closed-ended questions had been included (Adams & Cox, 2008). Additionally, participants may find open-ended questions less daunting, intrusive, or inconvenient than in-person interviews.

The use of both closed- and open-ended questions allows the advantages of each approach to be maximised whilst minimising the limitations of each type. For instance, open-ended questions can provide the deepest insight and minimise research bias. However, researchers such as Oppenheim (2000) and Cohen et al. (2007) note that open-ended questions generate data that are more demanding and challenging in terms of analysis. Furthermore, the variance in responses leads to a difficult task to compare respondents' answers systematically. The questions were designed to measure science teachers' beliefs and knowledge towards IBL and to investigate the implementation of IBL and its challenges.

4.4.3.1. Questionnaire Development

The questionnaire instrument contains five parts (see appendix C.2 for the questionnaire). The first part was designed to obtain demographic information about the participants.

The demographic information served the researcher to make a comparative study of the teachers according to their gender, experience, level of teaching, and specialisation.

The second part of the questionnaire was designed to answer the first research question about teachers' understandings of IBL. This part has two sections. In the first section, the participants were asked to answer the following open-ended question: 'from your perspective, how do you define IBL?'. The purpose of this question was to find out how well teachers understand IBL and to give the opportunity for participants to express their opinion freely and without any provided information.

Regarding the second section of the second part of the questionnaire, the items were designed in the form of IBL activities and teachers were asked to what extent they perceive these activities to represent IBL. This section has eleven items based on a five-point Likert scale (closed-ended questions) which contains nine items for inquiry activities and two items for non-inquiry activities. The participants were asked to place a mark in the most appropriate column according to their opinions. The inquiry activities in this section were designed in the light of the American National Research Council (2000) (NRC) definition of IBL. NRC (2000) defines IBL as following:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the

> results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p. 23)

The NRC definition was adopted for this study because the science textbooks in Saudi Arabia are based on a translation of an American series of science textbooks that was developed according to American National standards (refer to the study context chapter). Therefore, the characteristics of IBL in Saudi science textbooks correspond to NRC. Non-inquiry types of activities were also included in this section of the questionnaire to find out whether the participants could distinguish between inquiry and non-inquiry activities. The non-inquiry activities were derived from Harwood, Hansen, and Lotter (2006).

The purpose of the third part of the questionnaire instrument was to obtain data to investigate science teachers' actual use of IBL. This part of the questionnaire served to address the third research question 'how do Saudi science teachers implement inquiry-based learning in the classroom?'. The NRC definition of IBL was given to the teachers and then they were asked how often they teach according to the method defined for them on the questionnaire. In addition, they were asked how they implement IBL in their teaching. This question was helpful in determining the extent to which teachers apply the instructions given by MOE regarding IBL.

The fourth part of the questionnaire instrument was intended to collect relevant data for answering the second research question 'what are Saudi science teachers' beliefs about inquiry-based learning?'. This part aimed to measure to what extent Saudi science teachers believe in the importance and role of IBL in teaching science. More importantly, their perception of the relevance of IBL to the science textbooks that inherently rely on IBL teaching approach. The statements used in this part of the questionnaire come from official Saudi teacher guidance regarding IBL to identify whether science teachers agree with that or not. It contains 11 items, and the responses were based on a five-point Likert scale from strongly disagree to strongly agree.

The fifth part of the questionnaire instrument aims to address the research question 'what are the Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?'. This part was intended to investigate any potential issues and difficulties of IBL implementation from Saudi teachers' perspectives. This part was developed based on other research findings (Anderson, 2002; Capps et al., 2016; DiBiase & McDonald, 2015; Fitzgerald et al., 2019; Gillies & Nichols, 2015; Jones & Eick, 2007; Keys & Bryan, 2001; Kim et al., 2013; MASCIL, 2014; Ramnarain, 2016; Ramnarain & Hlatswayo, 2018; Roehrig & Luft, 2004; Zhang et al., 2005). By developing this part from the literature, it allowed comparison of Saudi teachers' perspectives with other research findings. This part contains 13 items, and the responses were based on a five-point Likert scale from 'not a challenge' to 'major challenge'. Also, it involves an open-ended question to give teachers the opportunity to raise any personally experienced issues.

4.5. Research Sample

The participants in the present research were drawn from a population which consisted of Saudi science teachers in three school stages (primary, middle, and high). This study involved two different samples: (1) observation and interview sample and (2) online questionnaire sample. The next paragraphs describe the research sampling strategies as well as the characteristics of participants for each sample.

4.5.1. Observation and Interview Sample

The observation and interview sample was chosen from different school stages (primary, middle, and high school) in the city of Mecca which is located in the western region of Saudi Arabia. It was anticipated that differences in the implementation of IBL could be found between different school levels. Thus, interviewing and observing science teachers throughout different school stages provided the opportunity to compare the findings.

The selection of observation and interview sample was limited to one city due to the following reasons. First, the Saudi Arabian educational context is similar which means that all science teachers have to teach the same exact science textbooks provided by the MOE. Second, it provided the opportunity to investigate teachers more in-depth and recruit many participants in a short period of time. Third, the researcher used to teach science in Mecca city, so he was familiar with the bureaucratic processes and this facilitated the accuracy and timely planning in obtaining the required approval letter from the administration of general education in Mecca. Fourth, Mecca city is one of the largest cities in Saudi Arabia which has a population with a wide range of different cultures and backgrounds, so a representative sample and meaningful results could be obtained.

Permission was obtained from the administration of general education in Mecca region to conduct classroom observations and interviews in different school levels. The administration of general education in Mecca sent their consent to all schools in the region. Only schools and science teachers that were willing to take part in this study were involved. So, participation in the present research was completely voluntary. The observation and interview sample involved 27 science teachers. This sample size helped to build a close relationship with participants and to gain in-depth data. As Crouch and McKenzie (2006) stress that “a small number of cases will facilitate the researcher’s close association with the respondents, and enhance the validity of fine-grained, in-depth inquiry in naturalistic settings” (p.483). The teachers who participated in the observation were then interviewed. By interviewing science teachers from the observation sample, the researcher was able to compare between their statements and their practices within classrooms. Most teachers were observed twice to obtain sufficient data and to check for consistent practice. The duration of each observation was 45 minutes (the full class duration in the Saudi system) while the interviews lasted about 15 to 20 minutes.

The following process was followed to create a productive research engagement with teachers. Firstly, I visited the schools at the beginning of the school day without prior coordination with the school principals or teachers and they were not aware of my visit. This was done to take every possible step to observe teachers’ natural practices and to avoid any change in their normal teaching or behaviours. I explained to the school principals the purpose of my visit to obtain their consent to conduct this study within their schools. Afterwards, the school principals gathered science teachers at their offices to introduce me and the purpose of my research to the teachers. Then, each science teacher in the visited school was given the opportunity to be engaged in the present study and to sign the consent form. Almost all teachers were willing to take part in the observations and interviews. Only a few teachers decided not to participate in the research.

Teachers were assured that I am not a representative of the MOE, and nor am I going to assess their teaching. Also, I introduced myself and explained to the teachers my role as a university researcher and former teacher. This step was important to build friendly professional relationships with teachers and to make it more likely that teachers would provide their answers freely. So, the teachers treated me as a friendly visitor. To put teachers at ease and to facilitate the data collection process, they chose the lessons in which they would be observed on the day of my visit. This was done to ensure that the teachers felt comfortable with my visit. Despite my efforts to observe teachers' natural practices, teachers' self-selection of the observed lessons on the day of my visit might influence the observational results. For example, some teachers may have chosen a lesson that reflects the best IBL scenario on the day of my visit.

The interviews took place immediately after the observations in quiet rooms within schools. I asked teachers to conduct face-to-face interviews with them after the observations to talk about their perceptions and practices of IBL. Although the teachers were willing to take part in this study, the level of their engagement in the data collection process was different. For example, some interviewees were very ready to discuss and explain their practice and thinking more than others. This could be influenced by some teachers potentially feeling insecure about their IBL practice or sensing a lack of knowledge about IBL, or it may be due to the nature of the person, where some people are more willing to talk and discuss than others. I had a sense that there were teachers in the first group (i.e., not talking because they felt insecure about their knowledge or practice), although it is not possible to conclude this with certainty.

The researcher could not access Saudi female schools for cultural and policy-related reasons. As an alternative, a qualified female research assistant was recruited to observe and interview the female science teachers. The female research assistant took full notes of what happened in the classroom. Also, the interviews were audio-recorded. The observation and interview data were then analysed by the researcher.

4.5.1.1 The Characteristics of the Observation and Interviewed Participants

The classroom observation and interviews were conducted between January to March 2019 with 27 science teachers across different school levels. The observations and interviews were conducted at 10 schools (5 primary, 3 middle, and 2 high) where the teachers taught science subjects. Demographic information about the observation and interview participants (gender, school levels, teaching experience, specialisation, and qualification) was presented in table 4.2 below.

Table 4. 2. Characteristics of the observation and interview participants

Participant Classification		Total (out of 27)
Gender	Male	19
	Female	8
School levels	Primary	9
	Middle	9
	High	9
Teaching experience	0-5 years	2
	6-10 years	8
	11-15 years	4
	16-20 years	5
	Over 20 years	8
Specialisation	Biology	9
	Chemistry	5
	Maths	1
	Physics	6
	General science	6
Qualification	Diploma	2
	Bachelor	24
	Masters	1

The Saudi school system is gender-segregated where male and female teachers and students attend separate buildings. However, the teaching of male and female students is organised in the same way and all male and female students attend schools until the age of 18. For this study, 8 female teachers were observed and interviewed due to the access permissions obtained for the arraignment with female schools. In contrast, the male schools were more accessible to the researcher than the female schools, thus, 19 teachers were involved in the observation and interview stages. Also, from each school level, 9 teachers participated in the interview. This was anticipated to give the opportunity to make a comparison between teachers according to their school levels. In addition, the sample of the teachers who participated has various lengths of teaching experience. However, most of the participants have been teaching science for more than

10 years. Furthermore, the majority of participants held bachelor's degrees (the minimum requirement for a teaching role in Saudi Arabia). Two of the participants did not hold bachelor's degrees because they were recruited before the qualification of bachelor's degrees requirement became into effect and those two teachers have been in the teaching profession for 29 years. Typically, science teachers in Saudi Arabia are specialists in biology, chemistry, or physics. Therefore, most of the participants are specialists in one of these science disciplines.

4.5.2. Online Questionnaire Sample

There are two broad techniques of selecting a research sample, probability sampling (also called 'random sampling') and non-probability sampling (Denscombe, 2010). The former is based on random selection, while the latter does not rely on random selection and it can be "used when researchers find it difficult or undesirable to choose their sample on the basis of pure chance" (Denscombe, 2010, p.25). For this study, non-probability sampling was utilised for the research study sample. This type of sampling was particularly chosen since there was no information that could justify randomising the population for the purpose of this research.

A self-administered questionnaire was created and distributed to the science teachers online through social media (such as Facebook and Twitter) and email. This allowed the researcher to reach a large sample population across the regions of the kingdom of Saudi Arabia, thus improving the representativeness of the results. In addition, the local department of education in Mecca region was asked to send the questionnaire via email to all science teachers in the region. Using online questionnaires offered many advantages. For example, data could be collected from a wide population, without geographical limitation, in a short period of time and at low cost (Bryman, 2016; Rice, Winter, Doherty, & Milner, 2017; Weber & Bradley, 2006). Furthermore, participants could complete the questionnaire in a convenient place and time; it also provides a better sense of anonymity (Bryman, 2016). Additionally, online questionnaires could reduce human error in the entry of data and coding, since responses can be automatically analysed and inserted into statistical packages, databases or spreadsheets (Fleming & Bowden, 2009). In contrast, one of the main limitations of online questionnaires identified in the literature is the potential lack of representativeness of the sample (Bryman, 2016; Rice et al., 2017; Weber & Bradley, 2006). However, this issue was minimised in this study by asking the local department of education to send the questionnaire to all science teachers and by distributing the questionnaire specifically to science teachers through several platforms. Also, teachers who received the questionnaire were asked to forward it to others.

Qualtrics software was used to design and collect online responses. This platform was used as it is sanctioned by the researcher's university and it was relatively easy to use. Also, free access to the Qualtrics platform was provided by the university. The next section presents the characteristics of the online questionnaire participants.

4.5.2.1 The Characteristics of the Online Questionnaire Participants

The questionnaire responses were collected over three months (January to March 2019). 288 responses were recorded. Teachers from different backgrounds participated in the online questionnaire. Table 4.3. below shows the characteristics of the online questionnaire participants.

Table 4. 3. Characteristics of the online questionnaire participants

Participant Classification		**Total (out of 288)**
Gender	Male	139
	Female	149
School levels	Primary	85
	Middle	77
	High	126
Teaching experience	0-1 years	12
	2-5 years	51
	6-10 years	81
	11-15 years	49
	16-20 years	43
	Over 20 years	52
Specialisation	Biology	91
	Chemistry	67
	Physics	60
	General science	29
	Other	41
Qualification	Diploma	10
	Bachelor	251
	Masters	22
	PhD	5

As shown in table 4.3 above, teachers from different school levels, experience, gender, specialisation, and qualification responded to the online questionnaire. Male and female participants were almost equal in number in the online questionnaire sample. This result could be attributed to the fact that male and female science teachers are almost equally distributed across different school stages in Saudi Arabia. Also, around 44% of the participants were high school teachers. This result was expected since the number of science teachers at the high school level is higher than in the middle and primary school levels in Saudi Arabia. Furthermore, most science teachers in Saudi Arabia hold bachelor's degrees in biology, chemistry, or physics. So, the majority of participants were specialists in one of these disciplines.

4.6. Data Analysis

This section discusses data analysis techniques and procedures for classroom observation notes, interviews, and online questionnaire. Each type of data collection method will be discussed separately.

4.6.1. Classroom Observation Analysis

Descriptive statistics, including frequencies and means, were conducted to analyse the classroom observation notes. The classroom observation notes were analysed by using the STIR rubric. As indicated in section 4.4.1, the STIR instrument evaluates six categories based upon the essential features of classroom inquiry defined by the NRC (2000). Each of the six categories of STIR instrument was measured on a scale of (0-4) based on the level of student self-direction. A rating of 0 indicates that no evidence for the inquiry category was observed. A rating of 1 indicates that the inquiry activity was more teacher-centred direction while a rating of 4 indicates the inquiry category was more student-centred direction.

The analysis of the classroom observation data was done through many stages to ensure the accuracy of the analysis. First, everything that happened in the lesson was recorded. For accuracy of recall, the observation rubric was initially completed immediately after the lessons. It was found from the pilot study that the observer may miss some of the main events if the observation rubric was completed during the lesson. So, completing the observation rubric after the lesson provided the opportunity for the observer to record everything that happened during the lesson. To increase the accuracy of the analysis, the observed lessons were also audio recorded so no activity or event was missed. This step helped the researcher to check and to revise at a later time the data in the observation rubric.

Microsoft Excel was used to analyse data in the observation rubric. Frequency and mean scores for each inquiry category in the observation rubric were calculated and tabulated for trends and patterns. Calculating the frequency of each inquiry category helped the researcher to find out the extent to which teachers implement the essential features of inquiry (NRC, 2000). As indicated earlier, teachers' practice of each essential feature of inquiry could be in a teacher-centred or student-centred direction. Therefore, mean scores were calculated to measure the direction of teachers' practice of each inquiry category.

4.6.2. Interview and Open-Ended Questionnaire Responses Data Analysis

As indicated earlier, 27 interviews were conducted in the schools setting. The interviews were audio-recorded and then the whole conversations were transcribed. Because the interviews were conducted in the Arabic language, the analysis of the interview data were initially carried out in the Arabic language and then translated into English. Interview data were analysed in their original language to avoid losing any relevant meaning in the translation process. Some extracts of the interviews that were used as quotes in this thesis were translated into English to illustrate findings and what the interviewees precisely expressed about the issues explored in the present research.

The thematic analysis approach (Bryman, 2016) was used to analyse the interview and open-ended questionnaire responses data. The thematic analysis followed disciplined steps that include translating the data to coding, generating themes from the codes, and finally producing a report from the themes. Braun and Clarke (2006) indicate that "thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data" (p.79). According to Attride-Stirling (2001), the analysis of initial raw data in a methodical manner enables organisation of the findings. Thus, the process of qualitative data analysis, for the current study, was carried out in two different ways: deductive and inductive. In the deductive analysis, the themes and codes were pre-determined and emerged from the research questions and the literature review. For example, NRC's (2000) definition of IBL was adopted for the present study to assess teachers' understandings of IBL (more detail in section 5.2). In contrast, the themes and codes were generated from the data in the inductive analysis phase.

Qualitative data were analysed manually by using Microsoft Word. A manual analysis was used for the qualitative data due to the lack of available qualitative data analysis software that supports the Arabic language. Also, the amount of data was manageable to be analysed manually. In order to analyse the qualitative data, the researcher followed closely the qualitative analysis process suggested by Creswell and Clark (2011) and Cohen et al. (2007), summarised below:

1- Transcribing all the recorded interviews and the answers to the open-ended questionnaire questions, using Microsoft Word.
2- Generating the initial codes and adding notes to the data.

3- Grouping the codes into categories or themes.

4- Making a comparison between categories and themes and then identifying interrelating themes.

5- Calculating the frequency and percentage for each category or theme.

6- Presenting and displaying the findings (figures, tables, theme passages).

7- Checking for the accuracy of the account (validity).

A Chi-square test of independence was performed to examine the relation between teachers' understanding of IBL and gender, teachers' school levels, experience, and specialisation. Chi-square is a non-parametric statistical technique designed to examine the differences between two or more categorical variables (McHugh, 2013). The Chi-square test was used in the present study for the following reasons. It is robust in terms of data distribution as it does not require homoscedasticity in the data or equal variances among the study categories; it is easy to compute; it provides detailed information about each variable; and it is flexible and can be used with two or more categories (McHugh, 2013).

4.6.3. Questionnaire Data Analysis

Descriptive statistics, including frequencies and percentages, were conducted in the present study to analyse the quantitative data collected from the closed-ended questions in the questionnaire. Also, some statistical tests were performed to examine the differences between the study variables. SPSS (Statistical Package for the Social Sciences) software version 25 was used to analyse the quantitative data in the online questionnaire. Next sections will provide more detail about the analysis of the questionnaire.

The analysis of the online questionnaire data was done through the following steps. Firstly, the data collected from the online questionnaire were exported from the Qualtrics platform into SPSS. Then, percentages, frequencies and means were calculated for each item to determine the most frequently repeated items. As indicated earlier, a five-point Likert scale was adopted to measure teachers' perceptions and beliefs about IBL. So, in order to calculate the mean scores and run some statistical tests in SPSS, the categories of responses were coded numerically (from 1 to 5). For example, the option 'strongly disagree' was coded as 1 and the option 'strongly agree' was coded as 5. The findings of the online questionnaire were then presented in tables and figures.

The Mann–Whitney U test and the Kruskal-Wallis test were performed to examine the differences in teachers' responses between sub-groups (gender, teaching school levels, experience, and specialisation). These two nonparametric statistical tests were used because the data on teachers' answers to Likert scale items were ordinal and not normally distributed (see appendix F for normality test). The Mann–Whitney U test is an alternative to the independent samples t-test, and it is used to examine the differences between two independent variables when the data are not normally distributed (MacFarland & Yates, 2016; McDonald, 2014; Mulhern & Greer, 2011). The Kruskal-Wallis test, on the other hand, is an alternative to the one-way ANOVA test which is typically used to compare three or more groups of independent variables when the data do not meet the normality assumption (McDonald, 2014). However, the Kruskal-Wallis test does not identify precisely where the differences between the groups lie. Therefore, when the result of a Kruskal-Wallis test showed that there was a statistically significant difference between the groups, a post-hoc Dunn's pairwise test was then carried out to determine which pairs of groups were significantly different. According to Dinno (2015) "Dunn's test is the appropriate nonparametric pairwise multiple comparison procedure when a Kruskal–Wallis test is rejected" (p. 292). Table 4.4 below shows the statistical tests that were used in the present study.

Table 4. 4. Statistical tests used in the present study

Dependent Variable	Independent Variable	Statistical test
Teachers' understandings of IBL, teachers' beliefs about IBL, and teacher' perceptions about the obstacles to using IBL	Gender	Mann–Whitney U
	Teaching school levels	Kruskal-Wallis and Dunn Pairwise
	Experience	Kruskal-Wallis and Dunn Pairwise
	Specialisation	Kruskal-Wallis and Dunn Pairwise

4.7. Pilot Study

The researcher conducted a pilot study to ensure that the study instruments (classroom observation, interview, and online questionnaire) meet the objectives of the research and achieve the design target. The pilot study aimed to check the clarity of the questions and the time needed to complete the interview and the online questionnaire. It also served to address any challenges that may be encountered during the execution of the main study and to discover any weaknesses in data collections tools. Also, the pilot study provided the researcher with the opportunity to conduct preliminary data analysis and to evaluate data analysis techniques. Next sections provide more detail about the pilot classroom observation, interview, and questionnaire.

4.7.1. Pilot Classroom Observation

The pilot observation was important to gain practical experience and to evaluate the observational rubric before the main study. Three science teachers were involved in the observation pilot study. As this study involved participants from three school levels (primary, middle, and high), one teacher in each school level was observed in the pilot study to gain practical experience in different school settings. The pilot observation provided the decision factors for necessary iteration for the number of classroom observations and the effective way of completing the observation notes. It was found that observing each teacher twice was adequate to understand to what extent the five essential features of inquiry (NRC, 2000) were implemented in the classroom. This was decided because the rating on the STIR instrument for each teacher was almost the same between the two observed lessons. Also, there was no notable difference in teachers' practice between the two lessons. Therefore, it was decided that it was not necessary to observe each teacher more than two times.

It was also found from the pilot study that observing teachers and completing the STIR instrument rating at the same time was not practical and some of the events during the lesson might be missed. So, it was decided to record all classroom activities during the lessons and then complete the STIR instrument rating immediately after the lessons. This also helped the researcher to see a full picture of the teachers' practices in the science classroom.

4.7.2. Pilot Interview

Pilot interviews were conducted with three science teachers to check the appropriateness and the clarity of the questions. It also helped the researcher to test the time needed to complete the interview, to get practical experience and identify any potential issues or challenges in conducting interviews, and to develop the skills necessary for carrying out semi-structured interviews.

Based on the pilot interviews, some changes were made to the interview questions. For example, the question 'would you describe this lesson as IBL?' was added as a follow-up question from the observation to identify whether the teachers perceive their practice in the observed lessons to be IBL or not. Also, it was found that some questions needed more clarification to ensure that teachers understood them correctly with their intended purpose. For instance, the question 'what is your role as a teacher in IBL?' was added in order to complement the question 'in inquiry-based learning, what is the teacher doing?' and to check and extend their answers. Similarly, the question 'what is the students' role in IBL?' was added to complement the question 'in inquiry-based learning, what are students doing?'.

4.7.3. Pilot Online Questionnaire

A pilot study of the online questionnaire was conducted with 10 science teachers. The online questionnaire was piloted to check the clarity of the questions, to determine the time needed for completing the questionnaire, and to test the online platform that was planned to be used for collecting the data. Based on feedback from the pilot study participants, some changes to the questionnaire were made. For example, the number of statements in question two of the second part of the questionnaire was shortened from 12 to 11 statements. The statement ‘students listen to the instructor lecture’ and ‘students receiving factual information from their teacher’ were merged into one statement, as follows: ‘students listen to the teachers lecture and receive information from them’. This was done because the participants interpreted these two statements in the same manner, which might be confusing. Also, some statements were revised to make them clearer and more comprehensible. For instance, the statement ‘the high demands of the curriculum’ was changed to ‘the curriculum contains a large amount of content that needs to be covered’. In another example, the statement ‘not enough classroom time’ was modified to ‘the class period is insufficient to apply IBL’. The next section discusses matters related to the validity and reliability of the research instruments.

4.8. Validity of the Study

According to Creswell (2012), the test of validity is intended to check the process of collection and analysis of data to ascertain that it was accurate from the researcher’s point of view. Cohen et al. (2007) emphasise that validity is required and essential in quantitative and qualitative research. Cohen et al. (2007) further suggest that the enhancement of validity can be achieved by considering different factors, which incorporate:

- The use of suitable strategies and instruments to provide answers to the research questions.

- The selection of an appropriate sample.
- The selection of an appropriate time to conduct the study.
- The availability of appropriate resources.

All the above-mentioned points were taken into account when carrying out this research. For instance, to accomplish the purpose of the research, the researcher adopted data collection instruments that are directly associated with the study questions. Furthermore, the researcher avoided leading questions and used explicit questionnaire and interview questions. Most significantly, it was expected that the participants would have the same understanding level of the questionnaire and interview questions (Adams & Cox, 2008), so the researcher can gain fair access to participants' opinions. Therefore, a pilot study was conducted to check the clarity of the questions. Also, all participants were asked precisely the same questions in a uniform manner and answers were recorded in an identical format. Cohen et al. (2007) assert that the internal validity can be increased by considering such steps.

Because the participants' language is not English, the instruments were translated into the Arabic language. For more validity, the translation was reviewed by two specialists in linguistics and Arabic-English translation. This step was essential to ensure that the questions were not ambiguous or misleading upon translating them into the Arabic language.

My experience in the field and my knowledge of Arabic and English languages were helpful in critically understanding teachers' responses. It increased my engagement with the data as I carefully read teachers' answers many times in order to understand them fully in Arabic and then interpret their answers in English as faithfully as possible. Also, my experience in the field, as a university lecturer and former science teacher, helped me in understanding the context in which the teachers were working. It also helped me in understanding the terms that teachers used in the interviews and questionnaires.

At the beginning of both the interview schedule and the questionnaire, teachers were given the opportunity to provide their understandings of IBL before being provided with any information that could influence their answers or their interpretations of IBL. This step was important for the validity of the questions about teachers' understanding of IBL because their interpretations of IBL were not contaminated by other understandings of IBL. In fact, simply knowing (e.g., from the consent forms) that they were taking part in a study about IBL might have prompted them to think about the "official" definition of IBL and whether their own ideas were "correct". This could have guided thinking, but it would have been unavoidable unless the participants were not fully informed of the purpose of the study. That would have been ethically inappropriate. However, the data suggest that there was no risk of demand characteristics on participants' responses because they gave answers that were not well aligned with the official definition of IBL.

For later sections about teachers' beliefs and implementation of IBL in the interview and questionnaire instruments, teachers were provided with a definition of IBL. As shown in the literature review chapter, teachers hold different conceptions of IBL and they may interpret it differently. So, it is problematic to assess teachers' beliefs and implementation of IBL without identifying a precise meaning of IBL. For this reason, in order to enhance the validity of the interview and questionnaire instruments, there was a need to identify a precise meaning of IBL in order to allow a meaningful comparison of teachers' views of IBL according to a common definition. So, teachers provided answers about their beliefs and implementation of IBL according to NRC's (2000) definition of IBL, which increases the internal validity of the study by focusing the data provided by the teachers onto a shared definition of IBL. However, another consequence is that the questions in the interview and questionnaire instruments about teachers' beliefs and implementation of IBL (and therefore the data provided at this stage) are only valid in relation to the NRC's (2000) definition of IBL. The NRC's (2000) definition of IBL was used for this study because the adopted science textbooks in Saudi Arabia are based on NRC's (2000) guidance, so it is contextually valid.

However, there was a possibility that the provided definition of IBL may have guided teachers' thinking concerning their beliefs about the importance of IBL because it might have highlighted to them what others (e.g., policy makers) consider to be essential or important features of IBL. For example, one limitation of the NRC's (2000) definition of IBL is that it could be considered not to clearly distinguish IBL from other forms of active learning. So, some teachers in this study might have thought that IBL is important because the provided definition of IBL includes many active learning activities. Also, the provided definition of IBL may have influenced teachers' answers to the questions about their implementation of IBL. For example, teachers may have thought that they implement IBL because the provided definition of IBL includes some learning activities that overlap with IBL.

4.9. Reliability of the Study

According to Creswell (2012), reliability means the test of the consistency or stability of groups of respondents, in order to boost the reliability and consistency of the study, and to report and document the entire procedures. Cohen et al. (2007) mention that reliability indicates that when a study is carried out once more with a similar context and sample, comparable findings or responses would be acquired. Despite this, results that are not exactly alike would be found between similar studies as well as different findings being obtained by researchers in a single study (Cohen et al., 2007). However, findings in both situations may still be reliable (Cohen et al., 2007).

Denscombe (2010) argues that one possible issue in qualitative research is that data may be interpreted in various manners by different researchers. Also, researchers often interpret other findings from the same data. So, it is difficult to judge the reliability of qualitative data because it is practically not possible to replicate a social setting (Denscombe, 2010). However, triangulation was used in this research to enhance the reliability of the collected data. Cohen et al. (2007) define triangulation as employing a different method of data collection to increase reliability. Cohen et al. (2007) and Denscombe (2010) articulate that researchers can apply several instruments to compare the findings with other sources of information on the topic and to ensure that the results are reliable. Therefore, different methods of data collection (questionnaire, classroom observations, and interviews) were used in the current study which gave the opportunity to confirm and compare the results from three data sources.

With regard to the interviews, face-to-face semi-structured interviews were conducted which helped the researcher to take passive notes about the participants' facial gestures and expressions. In addition, face-to-face communication assisted the researcher to attain a deeper understanding of the teachers' opinions. The necessary precautions were taken into consideration when conducting the interviews to ensure that the presence of the researcher did not influence participants' responses. For example, a neutral sound tone was used, and any extra commentary was avoided when talking to participants. The participants were assured that there was no right or wrong answer. Additionally, the questions were posed to the participants in an easily understood tone, and they were read exactly as worded.

The internal consistency (reliability) of the questionnaire was tested by using Cronbach's alpha test. As indicated by Taber (2018), Cronbach's alpha is one of the most frequently used tests to examine the internal consistency or the reliability of a questionnaire. Cronbach's alpha was developed "to provide a measure of the internal consistency of a test or scale" (Tavakol & Dennick, 2011, p. 53). Internal consistency represents the extent to which multiple items in an instrument gauge the same construct or concept (Tavakol & Dennick, 2011). The value of Cronbach's Alpha coefficient ranges from 0 (no internal consistency) to 1 (complete internal consistency) (Gliem & Gliem, 2003). Cohen et al. (2007, p. 506) provide guidance for interpreting the scores of Cronbach's alpha coefficient test as follows: >0.90 very highly reliable; 0.80-0.90 highly reliable; 0.70-0.79 reliable; 0.60-0.69 minimally reliable; <0.60 unacceptably low reliability. Table 4.5 below presents the results of Cronbach's alpha coefficient test for each scale of the questionnaire used in the present study.

Table 4. 5. The reliability of the questionnaire

Scale	Cronbach's alpha
Teachers' understandings of IBL	0.744
Teachers' beliefs about IBL	0.949
Teachers' perceptions about the obstacles to using IBL	0.882

As shown in table 4.5, the results of Cronbach's alpha coefficient test for all scales clearly indicate that the reliability of the questionnaire of the main study was secure.

The researcher could not access Saudi female schools for cultural and policy-related reasons. As an alternative, a qualified female research assistant was recruited to conduct the observations and interview sessions with the female science teachers. The research assistant has appropriate and relevant research experience as she holds a master's degree in education from the University of Manchester; furthermore, she is herself (at the time of the writing) conducting research for PhD in Education. In order to ensure the validity and reliability of the data, the researcher trained and prepared the research assistant on how to collect observation and interview data. Upon completing the data collection by the research assistant, all the data were analysed by the researcher.

As indicated in section 4.4.1, the Science Teacher Inquiry Rubric (STIR) developed by Bodzin and Beerer (2003) was used as an observation tool to measure teachers' practice of IBL in the present study. According to Bodzin and Beerer (2003), the STIR instrument should produce perfect inter-rater reliability (r=1) to be considered as a validated observation tool for IBL. However, to ensure the reliability of the observation analysis, the researcher and the research assistant rated the observation field notes for each lesson independently using the STIR instrument. Upon completing the rating, the results were compared and assessed the degree of agreement between the two scores, and we achieved 95% agreement on scores. Then we discussed any disagreements to gain consensus until 100% agreement was achieved.

4.10. Ethical Considerations

The researcher paid full attention to pertinent ethical issues when conducting this study and to adhere to the university guidelines. First, ethical approval was obtained from the departmental Ethics Committee at the University of York before collecting any data. In addition, permission was obtained from the administration of general education in Mecca and from headteachers to conduct this study. Only voluntary participation was considered, and the researcher provided consent forms for all participants which contained necessary information about the study. The participants were informed in writing of the purpose of the study. They also were assured that the data would be used in an anonymous format for only the present study and for educational purposes. The data have been held and treated confidentially by the researcher and stored securely on a password-protected computer which is only accessible to the researcher. The source of the data was not identifiable, no participant or school names were mentioned. The participants were informed that they were free to withdraw at any time during the data collection or up to 4 weeks after the data were collected for the case of observations and interview stages. Participants were given an opportunity to comment on a written record of their interview. Throughout the study, the researcher ensured the participants' privacy, followed the norms, and respected the local culture.

Chapter 5: Analysis and Findings of Teachers' Understandings of IBL

5.1. Introduction

This chapter presents the analysis and findings related to the first research question. The first research question was defined in Chapter 1 as follows:

> How do Saudi science teachers understand inquiry-based learning?

The data were collected from interviews and online questionnaires that took place between January and March of 2019 in Saudi Arabia. The details of how the interviews and online questionnaires were conducted were presented in Chapter 4. The focus of the interviews and online questionnaires was to study Saudi science teachers' perceptions of IBL. Precisely, the interviews and online questionnaires considered teachers' understandings and beliefs about IBL as well as how science teachers implement IBL and the challenges that the teachers might be facing. The questionnaire was conducted online, and the teachers were free to complete it at their convenience. The online questionnaire enabled the researcher to collect 288 responses of teachers across Saudi Arabia.

This chapter is organised into three major sections. The first section presents findings related to the analysis of qualitative data related to science teachers' understandings of IBL. The second section presents the quantitative findings related to science teachers' understandings of IBL. The third section presents a summary of this chapter.

5.2. Qualitative Findings Related to Teachers' Understandings of IBL

In order to understand how the Saudi science teachers understand the concept of IBL, teachers were asked in the interviews and the online questionnaire to provide their own definition of IBL. The participants' responses were then compared to the adopted IBL definition for this study (NRC's (2000) definition of IBL) to find out whether it is relevant or irrelevant to the adopted definition of IBL. This step enabled the researcher to measure participants' knowledge about IBL. The activities in the adopted definition of IBL were broken down and organised into terms. Each activity in the adopted definition of IBL was given a reference to facilitate the researcher to map the participants' answers during the analysis of teachers' responses (see table 5.1 below). The next section presents the interview findings related to the question 'how do you define IBL?'.

Table 5. 1. The IBL activities as defined in NRC (2000, p. 23)

IBL definition breakdown	Reference #
Making observations	1
Posing questions	2
Examining books and other sources of information to see what is already known	3
Planning investigations	4
Reviewing what is already known in light of experimental evidence	5
Using tools to gather, analyse, and interpret data	6
Proposing answers, explanations, and predictions	7
Communicating the results	8

5.2.1. Interview Findings Related to the Question 'How Do You Define IBL?'

Although teachers provided various understandings of IBL, some patterns emerged from their answers, and data generated from the interview transcripts were tabulated in table 5.2 below. The participants' answers contained the following exact terms: discovering information, deducing information, researching for information, collecting information, extracting students' prior knowledge, posing questions, solving problems, making observations, carrying out experiments, learner-centred approach, formulating hypotheses, and analysing information. In addition, some participants used multiple terms to define IBL while one participant explicitly answered having no idea of IBL. The key terms used in the participants' answers were extracted and classified into 'match', 'possible match or overlap', or 'no match' to the adopted IBL definition. Table 5.2 below summarises the terms extracted from the interviews related to the IBL definition and their classifications.

Table 5. 2. Data extracted from the interviews related to the question 'how do you define IBL?'

Terms in the answers to IBL definition	Teacher responding	Total teachers (%) N=27	Mapping answers to the adopted IBL definition (Reference #) *
Deducing information (drawing a conclusion)	T4, T7, T8, T15, T19, T23, T28	7 (26%)	Possible match or overlap (7)
Extracting students' prior knowledge	T5, T6, T11, T12, T22, T25	6 (22%)	Match (3,5)
Posing questions	T1, T3, T6, T10, T20	5 (18%)	Match (2)
Solving problems	T1, T17, T24, T25	4 (15%)	Possible match or overlap (2, 7)
Making observations	T1, T2, T8, T23	4 (15%)	Match (1)
Researching for information	T14, T15, T21	3 (11%)	Match (3, 5)
Answering questions	T1, T6, T20	3 (11%)	Match (7)
Discovering information	T15, T27	2 (7%)	Possible match or overlap (3, 5)
Carrying out experiments	T23, T26	2 (7%)	Match (6)
Not sure/confused	T13, T18	2 (7%)	No match
Analysing information	T15	1 (3%)	Match (6)
Collecting data	T2	1 (3%)	Match (6)
Formulating hypotheses	T26	1 (3%)	Match (7)
Having no idea of IBL	T9	1 (3%)	No match

*Reference of matching IBL activities to the adopted definition in table 5.1.

Table 5.2 above shows that the terms that were provided by the interviewed teachers could be classified into three categories. The first category includes terms that match the adopted definition of IBL such as posing questions and making observations. The second category involves terms that do not match any aspect of the adopted definition of IBL. The third category includes terms that possibly match the adopted definition of IBL. For instance, some teachers defined IBL as deducing information, but it is unclear what exactly they meant by the term "deducing". However, by reviewing their answers, "deducing" was potentially intended to mean that students draw a conclusion or reach an answer. To support this view, T4 said that "teachers extract idea and information that is intended to be learned from students because the students need to think and try to deduce and extract the correct information”. By reflecting upon T4’s statement it can be noted that T4 mentioned three aspects: thinking, deducing, and drawing a conclusion. In another example, T15 indicated many steps before deducing information by stating:

> Stimulate the student to discover information, research and investigate information, and analyse and deduce information. The teacher only shows the student the way of getting information, and then the student provides information.

It appears from T15’s quote that deducing is intended to mean reaching or drawing a conclusion, as T15 mentioned deducing information after analysing information (more details can be found in section 5.2.4.2). So, deducing in this context may be mapped to number 7 (proposing answers, explanations, and predictions) in table 5.1 above.

Complementing the analysis above about the contents of teachers' answers, their answers also have been analysed in terms of the depth of their answers and in this respect, there are five categories. The teachers’ answers to the question ‘how do you define IBL?’ were grouped into five categories. The five categories were developed based on the relevance of teachers’ answers to the adopted IBL definition. Table 5.3 shows interview responses classification related to the question ‘how do you define IBL?’.

Table 5. 3. Interview responses classification related to the question 'how do you define IBL?'

Response classification	Total teachers (out of 27)	Teacher's answer indicates
Participant stated that they had no Idea	1 (4%)	No knowledge
Non-relevant terms to the adopted definition	2 (7%)	Uncertain knowledge
One relevant term or possible relevant term to the adopted definition	15 (56%)	Basic knowledge
Two relevant terms or possible relevant terms to the adopted definition	5 (18%)	Fair knowledge
Three or more relevant terms or possible relevant terms to the adopted definition	4 (15%)	Good knowledge

The results of teachers' answers to the first interview question about their definition of IBL show that over half of the teachers (56%) mentioned one of the terms used in the adopted IBL definition (table 5.3) which was interpreted as those teachers having a basic knowledge of IBL. In contrast, two teachers (7%) appeared to have uncertain knowledge of IBL based on the non-relevant terms in their answers. Also, five teachers (18%) appeared to have a fair amount of knowledge by mentioning two of the terms (in table 5.1) in their answers. Only four teachers (15%) classified as having a good knowledge of IBL because they had given three of the terms in the adopted IBL definition.

5.2.2. Questionnaire Findings Related to the Open-Ended Question 'How Do You Define IBL?'

197 out of 288 participants responded to the open-ended question about teachers' own definitions of IBL. Teachers who responded to this question were classified, based on the relevance of their answers to the adopted IBL definition (table 5.1), into five groups which were: no knowledge, uncertain knowledge, basic knowledge, fair knowledge, and good

knowledge. The first group includes teachers who appeared to have no idea about IBL while the second group includes teachers who provided ideas that were unrelated to any aspect of the adopted IBL definition. The third group includes teachers who just mentioned one aspect of the adopted IBL definition. The fourth group involves teachers who mentioned two aspects of the adopted IBL definition. The last group involves teachers who stated three or more aspects of the adopted IBL definition. Table 5.4 below shows the classification of the questionnaire responses related to the question 'from your perspective, how do you define IBL?'.

Table 5. 4. Questionnaire responses classification related to the question 'from your perspective, how do you define IBL?'

Response classification	**Total teachers (out of 197)**	**Teacher's answer indicates**
Participant stated that they had no Idea	15 (7%)	No knowledge
Non-relevant term to the adopted definition	33 (17%)	Uncertain knowledge
One relevant term or possible relevant term to the adopted definition	97 (49%)	Basic knowledge
Two relevant terms or possible relevant terms to the adopted definition	31 (16%)	Fair knowledge
Three or more relevant terms or possible relevant terms to the adopted definition	21 (11%)	Good knowledge

As shown in table 5.4, nearly half of those who responded (49%) appeared to have a basic knowledge of IBL. They only indicated one relevant aspect or possible relevant aspect to the adopted IBL definition (table 5.1). In the following quote, for example, the teacher only described IBL as researching for a topic when said: "IBL depends on the research for a particular concept". In the same vein, another teacher commented that "IBL is about the student research for information by himself". Similarly, some teachers defined IBL only as posing questions. For instance, a teacher commented that "IBL is based on posing questions". In another example, a teacher defined IBL as "conducting experiments". In contrast, 31 teachers reported two aspects of IBL. For instance, a teacher indicated that "IBL is based on observation and experiments".

Only 21 out of 197 teachers (11%) reported three or more aspects of IBL which could indicate that those teachers had a good knowledge of IBL. For example, a participant indicated more than three aspects of IBL in the following quote: "IBL is based on experiment and practical testing and its scientific steps which are observation, formulating and testing a hypothesis, analysing and making a conclusion". So, in this example, the teacher provided many aspects of IBL such as carrying out experiments, formulating and testing a hypothesis, and analysing data. Likewise, another teacher commented that "IBL is a method that allows the learner to practise the scientific method and its operations alone, such as identifying the problem, collecting information, making observations, and making a conclusion".

15 out of 197 participants (7%) explicitly reported that they have no idea about IBL while 33 teachers (17%) provided ideas that were unrelated to the adopted IBL definition (table 5.1). For example, a teacher defined IBL as "using communication means such as the internet and public libraries". However, this teacher did not indicate for what purpose students use communication means. In another statement, a participant commented that "IBL can be done through the immersion in the secondary schools". In a further example, a teacher described IBL as cooperative learning. So, based on these examples, it seems that those teachers had uncertain knowledge about IBL as suggested by NRC (2000). This

finding could indicate that Saudi science teachers who do not have a clear concept of IBL as defined in NRC (2000) may be either unaware of this method of teaching or unwilling to admit it.

5.2.3. The Relationship Between Levels of Teachers' Knowledge About IBL and Different Variables (Gender, School Level, Experience, and Specialisation)

A Chi-square test of independence was performed to examine the relation between the level of teachers' knowledge of IBL and different variables (gender, school level, experience, and specialisation). The Chi-square test was performed for the combined set of the questionnaire and interview which comprised 224 participants who provided IBL definition (table 5.5 below summarises the characteristics of the teachers against their classified knowledge of IBL). The results of the Chi-square test showed that there were no significant associations between teachers who were categorised as having no knowledge of IBL and gender, years of experience, and school levels. However, there was a significant association ($p < .001$) in relation to teachers' specialisation. It was also found that non-science specialist teachers (the "other" group) had the highest percentage among those categorised as having no knowledge of IBL. This finding indicates that non-science specialist teachers are more likely to have a lack of knowledge about IBL.

With respect to those who were categorised as having uncertain, basic, or good knowledge of IBL, no significant associations were found in all factors i.e., gender, years of experience, school levels and specialisations. However, there was a significant association ($p= 0.011$) between teachers who were categorised as having fair Knowledge of IBL and their school levels. Other factors i.e., gender, years of experience, and specialisations had no significant effect on their definitions being categorised as fair knowledge (see appendix G for full results of the Chi-square test). The following section highlights the most reported themes that were extracted from the participants' responses to the question 'how do you define IBL?'.

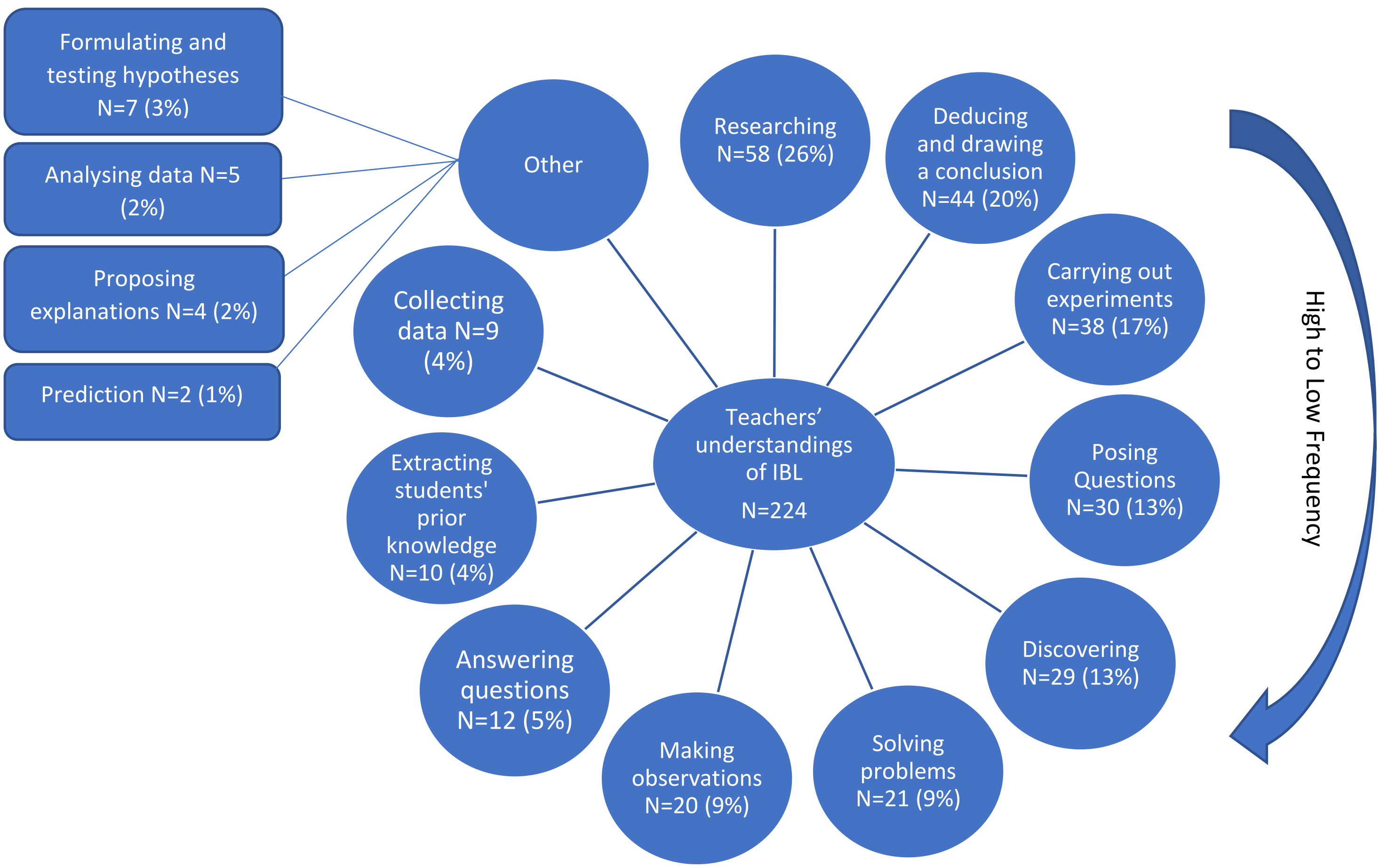
Table 5. 5**.** Characteristics of the teachers against their classified knowledge of IBL

Responses classification	**Gender**		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisation**				
	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
No Knowledge	11 (9%)	5 (5%)	5 (8%)	6 (9%)	5 (7%)	3 (9%)	5 (7%)	4 (10%)	1 (3%)	6 (17%)	3 (4%)	3 (6%)	1 (2%)	1 (3%)	8 (32%)
Uncertain Knowledge	20 (17%)	15 (14%)	13 (20%)	8 (12%)	14 (16%)	6 (17%)	7 (10%)	4 (10%)	5 (16%)	13 (27%)	15 (21%)	5 (9%)	6 (14%)	5 (17%)	4 (16%)
Basic Knowledge	59 (51%)	53 (49%)	36 (55%)	28 (41%)	48 (53%)	16 (46%)	38 (54%)	17 (42.5%)	16 (52%)	25 (52%)	33 (46%)	28 (53%)	23 (52%)	18 (60%)	10 (40%)
Fair Knowledge	14 (12%)	22 (20%)	4 (6%)	17 (25%)	15 (17%)	7 (20%)	10 (14%)	10 (25%)	4 (13%)	5 (10%)	13 (18%)	9 (17%)	9 (20%)	2 (7%)	3 (12%)
Good Knowledge	12 (10%)	13 (12%)	8 (12%)	9 (13%)	8 (9%)	3 (9%)	10 (14%)	5 (12.5%)	5 (16%)	2 (4%)	8 (11%)	8 (15%)	5 (11%)	4 (13%)	0 (0%)

5.2.4. Themes Extracted from Teachers' Answers to the Question 'How Do You Define IBL?'

Themes extracted from the interviews and the online questionnaire related to IBL definition were combined to get an overview on teachers' understandings of IBL. Figure 5.1 below illustrates the recurrent themes extracted from the interviews and questionnaire related to the question 'how do you define IBL?'.

Figure 5. 1. Themes extracted from teachers' answers to the question 'from your perspective, how do you define IBL?'



To facilitate the visual presentation of the findings, the terms used in the answers that had related meanings were presented under one broad theme. For example, the terms ‘researching for information’, ‘discovering information’, and ‘collecting information’ were presented under the theme ‘students find out information’ because they are all about students finding out information by themselves. Also, the terms ‘posing questions’, ‘solving problems’ and ‘formulating hypotheses’ were presented under the theme ‘posing questions and problems’ as they are all about giving students a task to be investigated. The following sections highlight the most frequently reported themes that were extracted from the participants’ responses to the question ‘how do you define IBL?’.

5.2.4.1. Students Find Out Information

As can be seen from figure 5.1 above, the most recurrent theme extracted from the interviews and the questionnaire responses related to IBL definition was a sense amongst participants that IBL is about finding something out. This theme includes responses that defined IBL as researching, discovering, and collecting information. However, teachers’ views were consistent in that students obtain information or knowledge by themselves. For example, in the interview when clarifying the meaning of IBL, T15 said:

> Stimulate the student to discover information, research and investigate information, and analyse and deduce information. The teacher only shows the student the way of getting information, and then the student provides information.

So, T15 used many terms to describe IBL such as ‘discover’ and ‘research’. However, T15 further described IBL by saying that “student provides information”. Therefore, the common feature of these terms in T15’s statement is that students try to learn by themselves rather than simply the teacher providing direct information to students. The next few sections provide more detail about the following sub-themes: researching, discovering, and collecting information.

5.2.4.1.1. IBL as Researching

As shown in figure 5.1 above, the findings from participants’ answers to the question ‘how do you define IBL’ indicated that the term of ‘researching’ was the most reported term. More than a quarter (26%) of those who responded to the open-ended question in the questionnaire felt that IBL is about researching. In contrast, 11% of the interview sample indicated this meaning of IBL in their answers. Searching for information, topics or concepts were all recorded by respondents. However, the majority of participants who mentioned this term indicated that IBL is about researching for information; this was noted in many of their statements. For example, one participant defined IBL as “learning by researching for information and discovery”. In another case, a participant thought that “IBL makes the student research for information by himself in the appropriate ways”. Also, another respondent described IBL as “researching for information and making sure it is correct”. Furthermore, T14 in the interview commented that IBL involves “student research for information or there is something that stimulates him to research for information”. Unlike the above-mentioned statements, a minority of respondents reported that IBL is about researching for concepts or topics. For instance, a teacher proposed that “IBL depends on the research for a particular concept”. Other participants commented that “IBL is about researching and making a conclusion around a particular topic”. This suggests that teachers may think that IBL is researching for specific information, and that they might also think that it is researching for more general ideas ('concepts') or for more broadly-based information (‘topics’).

Unlike the above-mentioned teachers, T21 specified two different types of IBL that can be used when students research for information, which are guided and open inquiry. T21 defined the guided and open inquiry as following:

> IBL depends on that student research for information by herself either by guided inquiry, where the teacher implements an experiment with the students and then students infer the results, or by open inquiry where the teacher only provides the question and students find out a conclusion.

To investigate whether there was a relationship between teachers’ understanding of IBL as researching and their genders, teachers’ school levels, experience, and specialisations, Chi-square tests of independence were performed. The outcome of the Chi-square tests showed that there were no statistically significant associations between defining IBL as researching and any of these teacher variables. Table 5.6 below shows the classification of the teachers who defined IBL as ‘researching’ and the Chi-square test results.

Table 5. 6. Classification of the teachers who defined IBL as researching and the Chi-square test results

IBL as researching	Gender		Teachers' school levels			Teaching experience					Teachers' specialisations				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	2 (out of 19)	1 (out of 8)	1 (out of 9)	0 (out of 9)	2 (out of 9)	0 (out of 2)	1 (out of 8)	0 (out of 4)	1 (out of 5)	1 (out of 8)	0 (out of 8)	2 (out of 5)	0 (out of 6)	0 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	26 (out of 97)	29 (100)	13 (out of 57)	20 (out of 59)	22 (out of 81)	11 (out of 33)	19 (out of 62)	9 (out of 36)	9 (out of 26)	7 (out of 40)	17 (out of 63)	16 (out of 48)	13 (out of 38)	4 (out of 24)	5 (out of 24)
Total	28 (24%)	30 (28%)	14 (21%)	20 (29%)	24 (27%)	11 (31%)	20 (29%)	9 (22.5%)	10 (32%)	8 (17%)	17 (24%)	18 (34%)	13 (30%)	4 (13%)	5 (20%)
P-value in the Chi square test	0.534		0.543			0.427					0.262				

5.2.4.1.2. IBL as Discovering

13% of participants who answered the open-ended question in the questionnaire and 7% of the interview sample stated that IBL is based on discovery, respectively. For instance, a teacher commented that "IBL is based on discovery and linking concepts". Similarly, another respondent reported that "IBL is a learning style that is based on discovery in order to acquire knowledge". Some participants provided more details about the discovery process as one teacher commented that "IBL is based on discovery which the student being able to produce knowledge by himself through the instruction of the teacher, experiments, questions or problems". Also, another participant reported, "guide students to find and discover the correct information through preliminary information presented to him or through various educational means". So, the above-mentioned teachers linked the concept of IBL to the discovery approach in which students discover knowledge by themselves.

Chi-square tests of independence were performed to examine the relation between teachers' understanding of IBL as discovering and their genders, teachers' school levels, experience, and specialisations. The Chi-square tests showed that there were no statistically significant associations between defining IBL as discovering and any of these teacher variables. Table 5.7 below shows the classification of the teachers who defined IBL as discovering and the Chi-square test results.

Table 5. 7. Classification of the teachers who defined IBL as discovering and the Chi-square test results

IBL as discovering	Gender		Teachers' school levels			Teaching experience					Teachers' specialisation				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	1 (out of 19)	1 (out of 8)	1 (out of 9)	0 (out of 9)	1 (out of 9)	1 (out of 2)	1 (out of 8)	0 (out of 4)	0 (out of 5)	0 (out of 8)	0 (out of 8)	1 (out of 5)	0 (out of 6)	1 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	16 (out of 97)	11 (100)	8 (out of 57)	5 (out of 59)	14 (out of 81)	3 (out of 33)	12 (out of 62)	4 (out of 36)	4 (out of 26)	4 (out of 40)	8 (out of 63)	6 (out of 48)	6 (out of 38)	6 (out of 24)	1 (out of 24)
Total	17 (15%)	12 (11%)	9 (14%)	5 (7%)	15 (17%)	4 (11%)	13 (19%)	4 (10%)	4 (13%)	4 (8%)	8 (11%)	7 (13%)	6 (14%)	7 (23%)	1 (4%)
P-value in the Chi square test	0.429		0.220			0.516					0.299				

5.2.4.1.3. IBL as Collecting Data

A small minority of participants mentioned collecting data when defining IBL. Only 3% of the interview sample indicated collecting data, which is similar to 4% of the survey sample. However, those participants also indicated many aspects of IBL besides collecting data. For instance, a respondent stated that “IBL is a method that allows the learner to practise the scientific method and its operations by himself, such as identifying the problem, collecting data, making observations, and making a conclusion”. So, from this teacher’s point of view, IBL has many practical steps including collection of information. Likewise, another teacher provided practical steps of IBL including observation, collecting data, and using tools in the following statement: “IBL is conducted through scrutinising information by observation, deducing information, using scientific research tools and collecting data outside and inside the school environment”.

In the interview, T2 provided some examples of the type of information that students can collect in the following statement, which includes a reference to data collections:

> IBL is about observation, constructing information, collecting information around a specific matter or idea. For example, collecting data about the impressions of the people or the impressions of the students around an idea; or I provide students with information and students investigate this information and then they obtain the results (e.g., numbers).

Consequently, T2 appeared to think that involving students in collecting survey data is a part of IBL.

Table 5.8 below shows the classification of the teachers who defined IBL as collecting data. Since more than 20% of the cells in the table 5.8 below have an expected value (count) less than 5, a chi-square test could not be used in a valid way to test for associations in the data.

Table 5. 8. Classification of the teachers who defined IBL as collecting data

IBL as collecting data	**Gender**		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisation**				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	1 (out of 19)	0 (out of 8)	0 (out of 9)	1 (out of 9)	0 (out of 9)	1 (out of 2)	0 (out of 8)	0 (out of 4)	0 (out of 5)	0 (out of 8)	0 (out of 8)	0 (out of 5)	1 (out of 6)	0 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	2 (out of 97)	6 (out of 100)	1 (out of 57)	5 (out of 59)	2 (out of 81)	2 (out of 33)	4 (out of 62)	1 (out of 36)	1 (out of 26)	0 (out of 40)	2 (out of 63)	2 (out of 48)	2 (out of 38)	2 (out of 24)	0 (out of 24)
Total	3 (3%)	6 (6%)	1 (2%)	6 (9%)	2 (2%)	3 (9%)	4 (6%)	1 (2.5)	1 (3%)	0	2 (3%)	2 (4%)	3 (7%)	2 (7%)	0

So, it is not the case that only older pupils are felt to be capable of IBL in the form of collecting data. Also, there is no evidence to indicate any significant association with gender, school level, teaching experience or specialisation.

5.2.4.2. IBL as Deducing

Around 26% of the interview sample and 20% of the participants who answered the open-ended question in the questionnaire mentioned deducing and making a conclusion when defining IBL. For instance, one participant said: "IBL is based on deducing by the learner through posing an idea or experiment to him". In another response, a teacher remarked that IBL is "giving the student an important role in deducing the information and searching for it and avoiding the method of delivering information directly". Similarly, a participant stated that "IBL is based upon the foundations, methods and strategies that make the learner arrive at and infer the information that is intended to be learned". Furthermore, a teacher reported that "it is a student-centred learning method where the students research, try, discover and make a conclusion". So, a key idea here is that students arrive at a conclusion by themselves rather than simply being given the information. This also can be supported by the following statement: "IBL does not rely on giving facts directly to the students, but to provide them with information that helps them to reach a law or theory".

Some teachers who defined IBL as deducing did not provide any further details about the procedure and the outcome that is involved in the deducing method of IBL. For instance, T4 described IBL as "teachers extract ideas and information that is intended to be learned from students, because the student needs to think and try to deduce and extract the correct information". Another example is that T8 stated that "IBL is based on observation and deduction, where the student plays a great role". Despite T8 combining observation and deduction, he did not provide details about the procedures of deduction. Similarly, T28 defined IBL by simply stating the student deduces information by himself.

Although some teachers provided detailed answers, their responses did not provide a clear logical account of the steps of deduction in a research process. For example, T7 and T23 stated what students deduce from, but they did not mention the steps of the deduction process involved. T7, when defining IBL, commented that:

> How the student reacts and deduces information by himself or in a group, we provide students with a sheet to conduct an investigation and exploration, or students deduce from their prior knowledge.

So, T7 mentioned two sources that students can deduce information from, either by engaging students in an investigation or from their prior knowledge. In contrast, T23 reported other sources for deducing information when stating that "the student deduces information from video presentations and model displays or from worksheets". In this statement, T23 indicated three sources that students deduce from: 1) video presentations 2) model displays, and 3) worksheets. Although T23 did not mention a specific example of worksheets, a worksheet typically includes a variety of activities and tasks to be accomplished by students. So, T7 and T23 only mentioned some sources of deduction information such as investigation, video presentations, model displays, and worksheets. However, they did not indicate what things these sources can do to guide students to think and deduce information. They did not seem to have a strong epistemological concept of the nature of deduction, in terms of the nature and philosophy of science.

Chi-square tests of independence were performed to examine the relation between teachers' understanding of IBL as deducing and their genders, teachers' school levels, experience, and specialisations. The Chi-square tests showed that there were no statistically significant associations between defining IBL as deduction and any of these teacher variables. Table 5.9 below shows the classification of the teachers who defined IBL as deducing and the Chi-square test results.

Table 5. 9. Classification of the teachers who defined IBL as deducing and the Chi-square test results

IBL as deducing	**Gender**		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisation**				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	5 (out of 19)	2 (out of 8)	3 (out of 9)	2 (out of 9)	2 (out of 9)	0 (out of 2)	2 (out of 8)	1 (out of 4)	1 (out of 5)	3 (out of 8)	2 (out of 8)	1 (out of 5)	1 (out of 6)	2 (out of 6)	1 (out of 1)
Questionnaire (N= 197)	17 (out of 97)	20 (100)	13 (out of 57)	8 (out of 59)	16 (out of 81)	7 (out of 33)	15 (out of 62)	8 (out of 36)	3 (out of 26)	4 (out of 40)	6 (out of 63)	11 (out of 48)	7 (out of 38)	8 (out of 24)	5 (out of 24)
Total	19 (16%)	22 (20%)	16 (24%)	10 (15%)	18 (20%)	7 (20%)	17 (24%)	9 (22%)	4 (13%)	7 (15%)	8 (11%)	12 (23%)	8 (18%)	10 (33%)	6 (24%)
P-value in the Chi square test	0.440		0.378			0.585					0.109				

5.2.4.3. Posing Questions and Problems

As shown in figure 5.1, another theme extracted from the analysis of the qualitative data was that IBL is about posing questions or problems. The interview findings revealed that 33% of participants who provided a definition of IBL indicated this aspect of IBL compared to 28% of the survey sample. However, posing questions was a more frequently reported term than posing problems or hypotheses. The following section presents the findings related to the theme of 'posing questions'.

5.2.4.3.1. IBL as Posing Questions

When teachers were asked, in the interviews, to define IBL, five of them mentioned posing questions. Two teachers seem to have a narrow understanding of IBL because they think IBL is only about questioning which is just one aspect of the essential features of inquiry as cited in NRC (2000). For example, T10 defined IBL as "questions that make the student remember as brainstorming". In the same way, T20 interprets IBL as "ask a question and wait for answers". The other three teachers indicated other aspects of IBL with posing questions. For instance, T1 commented that:

> My understanding of IBL is posing questions to seek answers or posing a problem then seeking a solution for it by scientific research method and visual presentations or worksheets.

Although T1 was asked to clarify what he means by "scientific research method", he did not provide any more details about it.

T3 also considers IBL as asking questions when stating that:

> IBL depends on questions around a specific topic, which means you inquire about a topic or gain knowledge about it by questions as if you would like to inquire about something (e.g., its history, its meaning) you are collecting a lot of information about it by questions.

It can be noticed that the above responses tend to focus on teacher-oriented questions, and no one mentioned students posing questions in the interviews.

With regards to the open-ended question in the questionnaire, 26 out of 197 participants reported posing questions when defining IBL. However, the way of posing questions was often inconsistent between teachers and it could be categorised into three groups: teacher-directed questions, student-directed questions, and non-determined questions.

The teacher-directed question was reported by 11 teachers. For instance, a participant commented that “IBL is about posing a variety of high-level questions to the student during learning and it is divided into two types guided and unguided”. Although the teacher here indicated two types of IBL (guided and unguided), he only reported teacher-directed questions. Likewise, another participant stated that “IBL makes the student the focus of the learning process by posing questions to him”. On the other hand, only three teachers indicated student-directed questions. For example, a teacher indicated a student-directed question in the following statement: “the student research and posing questions to the teacher”. Similarly, another participant mentioned that “IBL is a student-centred learning method that focuses on asking questions. Students are encouraged to ask meaningful questions for them”. 11 teachers did not specify who is posing the questions as in the following statement “IBL is about posing questions to think”.

In spite of the fact that 26 participants mentioned posing questions when defining IBL, only nine teachers indicated answering questions. For example, a teacher described IBL as “posing questions and encouraging students to provide a lot of answers”. Also, another participant reported that “IBL is educational or instructional practices that are conducted by the learner to reach new information by answering specific questions”. So, it seems from this particular response that the teacher connected the process of learning new information to answering questions. Similarly, a participant described how the information is developed in IBL by saying “the information is built after questions are posed and answered after several stages of experiments”.

The understanding of IBL as posing questions was cited in the interviews and the open-ended question in the questionnaire by science teachers from different genders, school levels, experience, and specialisations (as shown in table 5.9 below). However, the outcome of the Chi-square test showed that there was a statistically significant association with gender, X^2 (1, N = 224) = 9.469, p = .0021. Male teachers were more likely than female teachers to describe IBL as posing questions. Table 5.10 below shows the classification of the teachers who defined IBL as posing questions and the Chi-square test results.

Table 5. 10. Classification of the teachers who defined IBL as posing questions and the Chi-square test results

IBL as posing questions	**Gender**		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisation**				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	5 (out of 19)	0 (out of 8)	1 (out of 9)	2 (out of 9)	2 (out of 9)	0 (out of 2)	2 (out of 8)	1 (out of 4)	2 (out of 5)	0 (out of 8)	2 (out of 8)	2 (out of 5)	1 (out of 6)	0 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	19 (out of 97)	7 (out of 100)	4 (out of 57)	11 (out of 59)	11 (out of 81)	2 (out of 33)	5 (out of 62)	9 (out of 36)	4 (out of 26)	6 (out of 40)	12 (out of 63)	5 (out of 48)	6 (out of 38)	1 (out of 24)	2 (out of 24)
Total	24 (21%)	7 (6%)	5 (8%)	13 (19%)	13 (14%)	2 (6%)	7 (10%)	10 (25%)	6 (19%)	6 (12.5%)	14 (19%)	7 (13%)	7 (16%)	1 (3%)	2 (8%)
P-value in the Chi-square test	*0.002		0.150			0.097					0.234				

* The result is significant at p < .05.

5.2.4.3.2. IBL as Solving Problems

Another concept that emerged from the qualitative data was that IBL means solving problems. 15% of the interview sample associated IBL with solving problems compared to 9% of the questionnaire sample.

Among the interviewed teachers, four out of 27 teachers indicated this meaning of IBL. T1 in his statement commented that “raising a problem then seeking a solution for it by scientific research method”. Also, T24 and T25 described IBL as giving problems and searching for solutions for them. Unlike T1, T24, and T25, T17 provided more practical steps when he reflected: “students have a problem and start to investigate it. For example, why this problem happened, what can I do to solve it, propose solutions that help to overcome this problem”. So, T17 suggested three aspects of solving a problem: (1) students investigate the reasons behind a problem, (2) students understand their personal role to solve the problem, and (3) students propose solutions to the problem.

Regarding the open-ended question in the survey, 21 out of 197 teachers reported posing and solving problems in their answers to the definition of IBL. However, only four teachers provided details on the manner of solving problems. For example, a teacher commented that “IBL is a kind of learning that is based on problem-solving through its different stages: observe, ask, formulate and test a hypothesis and verify the results”. In the same vein, a participant stated that “IBL is a learning process that is based on the scientific approach to solve a problem, which begins from reviewing the previous studies to analysing data and making a conclusion”. In contrast, 11 teachers did not provide any details about the process of solving problems. Supporting this view, a participant stated that “IBL is about searching for a solution to a problem”. In addition, another teacher commented that “IBL is based on solving a problem, the student finds out a solution to a problem from his perspective and from his prior knowledge”.

Chi-square tests of independence were performed to examine the relation between teachers' understanding of IBL as solving problems and their genders, teachers' school levels, experience, and specialisations. The outcome of the Chi-square tests showed that there were no statistically significant associations between the likelihood of regarding IBL as solving problems and of these teacher variables. Table 5.11 below shows the classification of the teachers who defined IBL as solving problems and the Chi-square test results.

Table 5. 11. Classification of the teachers who defined IBL as solving problems and the Chi-square test results

IBL as solving problems	**Gender**		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisation**				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	2 (out of 19)	2 (out of 8)	1 (out of 9)	1 (out of 9)	2 (out of 9)	0 (out of 2)	2 (out of 8)	1 (out of 4)	0 (out of 5)	1 (out of 8)	2 (out of 8)	2 (out of 5)	0 (out of 6)	0 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	5 (out of 97)	12 (out of 100)	4 (out of 57)	6 (out of 59)	7 (out of 81)	2 (out of 33)	4 (out of 62)	4 (out of 36)	4 (out of 26)	3 (out of 40)	6 (out of 63)	4 (out of 48)	5 (out of 38)	2 (out of 24)	0 (out of 24)
Total	7 (6%)	14 (13%)	5 (8%)	7 (10%)	9 (10%)	2 (6%)	6 (9%)	10 (25%)	4 (13%)	7 (15%)	8 (11%)	6 (11%)	5 (11%)	2 (7%)	0
P-value in the Chi-square test	0.075		0.835			0.088					0.903				

5.2.4.4. IBL as Carrying Out Experiments

A further theme that emerged from the qualitative data regarding teachers' understanding of IBL was that IBL means carrying out experiments. Two of the interviewed teachers indicated this understanding of IBL. For example, T23 commented that "IBL is based on experiments, taking notes, models display, video presentations, worksheets”. T23 is an example of teachers who included ‘experiments’ in their definition, but without specifically relating to IBL. The definition of IBL from T23 is very broad and includes many other aspects. T26 also included experiments when stating that “IBL depends upon quantitative analysis that is based on formulating hypotheses and then carrying out experiments”. Interestingly, T26 is the only teacher who mentioned that IBL depends upon quantitative analysis. That could be associated with her being a high school physics teacher.

With regard to the open-ended question, 36 (18%) out of 197 participants included experiments when describing IBL. Some teachers only described IBL as carrying out experiments. For example, a teacher noted that “IBL is based on experiments”. In the same way, another participant reported that “IBL is about carrying out experiments”. In contrast, other teachers indicated more detailed answers or other activities with experiments. Supporting this view, a respondent defined IBL as “in IBL, information is obtained after conducting an experiment or research, and it includes the use of the students’ skills of comparison, experimentation, observation, measurement and prediction”. So, in this example the teachers mentioned several activities such as experimentation, observation, and prediction. Likewise, another teacher indicated the steps of experiment in the following statement “IBL is based on experiment and practical work with its scientific steps which are observation, development and test of hypothesis, analysis and making a conclusion”. Also, another teacher described IBL as a learning approach that allows students to acquire knowledge not only from experiments but also from multiple activities in the following statement: “IBL makes the student extract information and knowledge through research, question, picture, presentation or practical experiment".

By comparing between the sup-groups who included experiments in their definition of IBL in the qualitative data It can be noted that female teachers indicated experiment in their answer more than male teachers. The outcome of the Chi-square test showed that there was a statistically significant association with gender, X^2 (1, N = 224) = 11.890, p = .0006. Female teachers were more likely than male teachers to describe IBL as carrying out experiments. Table 5.12 below shows the classification of the teachers who defined IBL as carrying out experiments and the Chi-square test results.

Table 5. 12. Classification of the teachers who defined IBL as carrying out experiments and the Chi-square test results

IBL as carrying out experiments	**Gender**		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisation**				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	0 (out of 19)	2 (out of 8)	0 (out of 9)	1 (out of 9)	1 (out of 9)	0 (out of 2)	1 (out of 8)	0 (out of 4)	0 (out of 5)	1 (out of 8)	1 (out of 8)	0 (out of 5)	1 (out of 6)	0 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	10 (out of 97)	26 (out of 100)	10 (out of 57)	13 (out of 59)	13 (out of 81)	4 (out of 33)	12 (out of 62)	10 (out of 36)	7 (out of 26)	3 (out of 40)	15 (out of 63)	8 (out of 48)	8 (out of 38)	4 (out of 24)	1 (out of 24)
Total	10 (9%)	28 (26%)	10 (15%)	14 (21%)	14 (16%)	4 (11%)	13 (19%)	10 (25%)	7 (23%)	4 (8%)	16 (22%)	8 (15%)	9 (20%)	4 (13%)	1 (4%)
P-value in the Chi-square test	*0.000		0.632			0.202					0.268				

*The result is significant at p < .05.

5.2.4.5. IBL as Making Observations

Another theme that was extracted from the qualitative data of the teachers' answers to the definition of IBL was making observations. Four teachers in the interviews mentioned observations when describing IBL. However, only two of them indicated that making observations is a key aspect of IBL. T23 indicated the making of empirical observations, alongside other types of observations, when stating that IBL involves "students making observations through experiments, models display, and video presentations". In contrast, T1 reported only non-empirical observation when he said, "students are shown videos and making observations from them". So, T23 explicitly mentioned making empirical observations as opposed to T1, T2, and T8 who mentioned observations in their statements but without specifying an empirical inquiry context.

With regards to the open-ended question in the questionnaire, around 8% (16 participants) who responded to the open-ended question included observation when defining IBL. However, two teachers described IBL as observation only while the other 14 teachers mentioned observation with other activities. For instance, a teacher noted that "IBL is based on observation". That could be viewed as a narrow understanding of IBL since only one aspect of IBL (observation) was provided. In a similar manner, another participant commented that "IBL is based on observation and data recording". In contrast, a broader perspective has been reported by many teachers. For instance, a respondent suggested that "IBL is based on observation, prediction and experimentation and verification". Another teacher alluded to a notion of IBL that includes observation by stating that:

> IBL is a learning that aimed to collect a lot of information and concepts about a scientific topic, whether by observing or conducting experiments or by scientific thinking and allowing the student to express his opinion and ideas freely in relation to this topic.

Although teachers did not provide more details about the methods of making observations, five teachers connected observation to experiment. Thus, those five teachers might be referring to empirical observations.

Based on the analysis of qualitative data, the understanding of IBL as making observations was more reported by teachers from the middle school level than the other school levels. The outcome of the Chi-square test showed that there was a statistically significant association with teachers' school levels, X^2 (2, N = 224) = 9.970, p = .0068. Middle school teachers were more likely to describe IBL as making observations than primary and high school teachers. The meaning of this statistically significant finding is discussed in section 9.2.7. Table 5.13 below shows the classification of the teachers who defined IBL as making observations and the Chi-square test results.

Table 5. 13. Classification of the teachers who defined IBL as making observations and the Chi-square test results

IBL as making observation	Gender		Teachers' school levels			Teaching experience					Teachers' specialisation				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	3 (out of 19)	1 (out of 8)	1 (out of 9)	3 (out of 9)	0 (out of 9)	1 (out of 2)	1 (out of 8)	1 (out of 4)	0 (out of 5)	1 (out of 8)	1 (out of 8)	1 (out of 5)	2 (out of 6)	0 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	6 (out of 97)	10 (out of 100)	4 (out of 57)	9 (out of 59)	3 (out of 81)	3 (out of 33)	7 (out of 62)	2 (out of 36)	3 (out of 26)	1 (out of 40)	7 (out of 63)	2 (out of 48)	4 (out of 38)	2 (out of 24)	1 (out of 24)
Total	9 (8%)	11 (10%)	5 (8%)	12 (18%)	3 (3%)	4 (11%)	8 (11%)	3 (7.5%)	3 (10%)	2 (4%)	8 (11%)	3 (7%)	6 (14%)	2 (7%)	1 (4%)
P-value in the Chi-square test	0.524		*0.006			0.686					0.516				

*The result is significant at p < .05.

5.2.4.6. IBL as Extracting Students' Prior Knowledge

Another reported theme that emerged from the qualitative data was extracting the prior knowledge from students. Six teachers (22%) indicated this meaning of IBL in the interviews while four teachers (2%) mentioned it in the open-ended question in the questionnaire. Those teachers claimed that each student has some ideas and experience around a topic, therefore they try to construct knowledge from them. Teachers here did not refer to a specific pedagogy, rather a broad interpretation was raised. This interpretation is similar to constructivism theory which has been emphasised by policy makers in Saudi Arabia (refer to Chapter 2 for more details). Therefore, this could impact teachers' understandings of IBL. For instance, T5 indicated that "IBL means extracting the prior knowledge from students, and then the teacher adds or corrects the information". Likewise, T6 described IBL as "encouraging students to say the information that they have, either through prior information or through questions and answers". Also, T11 commented that "IBL depends on the prior information and lets students think about life, how we can benefit from the lesson in the normal life". T12 also mentioned that IBL means "extracting the prior information and experiences that the learner has". T12 also argued that "it is impossible that students have no idea, so, I benefit from that". So, T12 assumed that students would have ideas on the topic being taught which can contribute to their understandings. Finally, T25 defined IBL simply by saying that it is "investigating students' prior knowledge".

The understanding of IBL as extracting students' prior knowledge was reported by teachers across all school levels. However, it was more common among middle school teachers. Also, none of the newly qualified teachers indicated this meaning of IBL. In addition, most of the teachers who reported this understanding of IBL have been teaching for 6-10 years or over 20 years. However, there is no evidence to indicate any significant association with gender, school level, teaching experience or specialisation. Since more than 20% of the cells in the table 5.14 below have an expected value (count) less than 5, a chi-squared test could not be used in a valid way to test for associations in the data. Table 5.14 below shows the classification of the teachers who defined IBL as extracting the prior knowledge from students.

Table 5. 14. Classification of the teachers who defined IBL as extracting students' prior knowledge

IBL as extracting students' prior knowledge	Gender		Teachers' school levels			Teaching experience					Teachers' specialisation				
Source of data	Male N=116	Female N=108	Primary N=66	Middle N=68	High N=90	0-5 years N=35	6-10 years N=70	11-15 years N=40	16-20 years N=31	Over 20 years N=48	Biology N=72	Chemistry N=53	Physics N=44	General science N=30	Other N=25
Interviews (N= 27)	4 (out of 19)	2 (out of 8)	1 (out of 9)	3 (out of 9)	2 (out of 9)	0 (out of 2)	1 (out of 8)	1 (out of 4)	1 (out of 5)	3 (out of 8)	1 (out of 8)	2 (out of 5)	1 (out of 6)	2 (out of 6)	0 (out of 1)
Questionnaire (N= 197)	1 (out of 97)	3 (out of 100)	1 (out of 57)	3 (out of 59)	0 (out of 81)	0 (out of 33)	3 (out of 62)	0 (out of 36)	0 (out of 26)	1 (out of 40)	0 (out of 63)	1 (out of 48)	2 (out of 38)	0 (out of 24)	1 (out of 24)
Total	5 (4%)	5 (5%)	2 (3%)	6 (9%)	2 (2%)	0	4 (6%)	1 (2.5%)	1 (3%)	4 (8%)	1 (1%)	3 (7%)	3 (7%)	2 (7%)	1 (4%)

5.2.4.7. Other Responses to the Meaning of IBL

As can be seen from figure 5.1, some understandings of IBL were rarely mentioned by participants in the qualitative data which were: formulating and testing hypotheses, prediction, analysing data, and proposing explanation. For example, seven out of 224 teachers indicated formulating and testing hypotheses when defining IBL. Also, four participants mentioned proposing explanations in their definition of IBL. Furthermore, only two participants cited prediction when describing IBL.

5.2.5 Summary of the Qualitative Findings Related to the Question 'How Do You Define IBL?'

Overall, participants mentioned different concepts to describe IBL such as researching, deducing, discovering, posing questions and problems, carrying out experiments, and making observations. However, their answers were consistent with a view that IBL is about active learning – in other words, a pedagogy that, to some extent at least, has learners in a role that is not entirely passive. Also, the findings indicated that half of the participants who provided their own definition of IBL appeared to have only a basic knowledge of IBL because they mentioned just one aspect of IBL as suggested by NRC (2000) while a minority of participants (11%) seemed to have good knowledge of IBL, since they indicated three or more aspects of IBL as defined by NRC (2000). Furthermore, the most frequent term used by the participants to describe IBL was 'researching', which is a very broad term. The next section presents findings related to the origin of teachers' knowledge of IBL.

5.2.6. The Origin of Teachers' Understandings of the Meaning of IBL

The second question about teachers' understandings of IBL in the interviews was 'how did you develop these understandings about IBL? When and where did you learn about IBL?'. Teachers were asked this question in order to find out how they developed their understandings of IBL. Some teachers indicated that they have developed their understanding of IBL from more than one source. For example, T8 developed his understanding of IBL through self-reading and the official school science textbooks. Table 5.15 below shows the origin of teachers' understandings of the meaning of IBL.

Table 5. 15. The origin of teachers' understandings of the meaning of IBL

The origin of teachers' developments of the meaning of IBL	**Teachers responding**	**Frequency (N=27)**
Self-reading	T1, T7, T8, T14, T15, T18, T22, T23, T28	9 (%33)
Course at university	T2, T10, T13, T17, T20	5 (%18)
Official school science textbooks	T3, T8, T17, T22, T24, T27	6 (%22)
Professional development and training	T3, T6, T10, T11, T14, T15, T21, T24, T25, T26, T28	11 (%40)
Experience	T4, T12, T19, T20	4 (%15)
Discussion with colleagues	T4, T5, T10, T27	4 (%15)

As shown in table 5.15, 40% of those who were interviewed indicated that they developed their understandings of IBL from professional development trainings, while 33% developed it through self-reading. Also, 22% of the participants reported that they developed their understandings of IBL from the official school science textbooks. In addition, other sources of teachers' developing understandings of the meaning of IBL that were less frequently reported by the participants included: course at university, experience, and through discussion with colleagues.

When comparing the classification or responses regarding the adopted definition of IBL (table 5.3) with the origins of teachers' understandings of the meaning of IBL (table 5.15), certain paradoxical findings can be noted. For example, five out of the six teachers who developed their understanding of IBL from the official school science textbooks had given definitions of IBL that implied having either uncertain or basic knowledge about IBL. In addition, two teachers who were classified as having good knowledge about IBL (table 5.3) developed their understanding of IBL through self-reading. These findings raise concerns about the reach and effectiveness of the official sources provided by MOE in Saudi Arabia, such as professional development training programs and the science textbooks, in providing teachers with adequate knowledge about IBL. Table 5.16 below summarises these findings.

Table 5. 16**.** A comparison between interview responses to the question 'how do you define IBL?' (table 5.3) and the origin of teachers' understandings of the meaning of IBL (table 5.15)

The origin of teachers' developments of the meaning of IBL (table 5.15)	**Classified response based on the adopted definition of IBL (table 5.3)**			
	Uncertain knowledge	Basic knowledge	Fair knowledge	Good knowledge
Self-reading	T12, T18	T7, T14, T22, T28	T1, T8,	T15, T23
Course at university	T13, T17	T10, T20	T2	
Official school science textbooks	T17, T24, T27	T3, T22	T8	
Professional development and training	T24	T3, T6, T10, T11, T14, T21, T25, T28	T26	T15
Experience		T4, T12, T19, T20		
Discussion with colleagues	T27	T4, T5, T10		

Although the policy makers in Saudi Arabia have emphasised IBL and adopted science textbooks based on it (refer to Chapter 2 for details), only six out of 27 (22%) teachers stated that they developed their understandings of IBL through the school science textbooks. That may help interpret why science teachers hold different views about IBL. In addition, this finding suggests that there is a gap that may exist between policy makers in Saudi Arabia and teachers because almost half of the teachers who were interviewed developed their understanding about IBL from sources other than MOE's guidance. Therefore, the implementation of IBL might not be proceeding as intended by policy makers in Saudi Arabia because the policy is diluted and re-interpreted by the other sources or indeed the other sources may be completely independent and unrelated to the MOE's guidance. Furthermore, it appears from the analysis of the interviews that there is no association between what teachers think about IBL and where they got their ideas from.

5.2.7. Teachers' Perceptions of IBL Activities

In the interviews, teachers were further asked 'what type of teaching practices (activities) take place when using IBL?' to gain more understanding about their views of IBL and in practice to substantiate the teachers' answers in the first interview question. The teachers' stated IBL activities were classified and compared to adopted IBL definition-derived activities from table 5.1. The results are shown in table 5.17 below.

Table 5. 17. Interview results about IBL activities mentioned by the participants

Activities mentioned by the participants	**Teachers responding**	**Total teachers**	**Mapping answers to the adopted IBL definition (Reference #) ***
Experiments	T5, T8, T17, T18, T21, T22, T23, T26, T27, T28	10	Match (6)
Questions	T1, T3, T6, T7, T10, T11, T12, T15, T22	9	Match (2)
Group work or cooperative learning	T3, T4, T9, T10, T18, T19, T20, T21, T24	9	No match
Video and/or picture presentations	T1, T6, T7, T8, T12, T23, T25, T27	8	Possible match or overlap (1)
Researching	T7, T14, T17, T20, T24, T25	6	Match (3, 5)
Discussion	T3, T4, T13, T17	4	Possible match or overlap (7)
Observation	T12, T17, T21	3	Match (1)
Scientific models	T12, T23	2	Match (1)
Communication	T18, T24	2	Match (8)
Homework	T3, T19	2	No match
Data collection	T2	1	Match (6)
Data analysis	T2	1	Match (6)
Formulate a problem	T5	1	Possible match or overlap (2)
Giving examples	T8	1	No match
A summary of a lesson	T10	1	No match
Proposing answers	T24	1	Match (7)

*Reference of matching IBL activities to the adopted definition in table 5.1.

It is apparent from table 5.17 that the most reported activity mentioned by participants in the interviews was 'experiments'. Of the 27 participants, more than one-third (37%) mentioned experiments when they were asked about the activities of IBL. In addition, other activities that were frequently reported included: questions, cooperative learning, video and/or picture presentations, and researching. However, some of these activities mentioned by teachers are not in alignment with the adopted definition of IBL for this study, which included: group work or cooperative learning, homework, giving examples, and a summary of a lesson.

When teachers were asked ‘what type of teaching practices (activities) take place when using IBL?’ they reported more IBL activities that are in alignment with the adopted IBL definition than when they were asked to define IBL in the first interview question ‘how do you define IBL?’. This finding could indicate that some teachers might have a lack of explicit, structured knowledge about IBL, but they implement some aspects of IBL in their practice nevertheless. Supporting this view, one teacher commented that “we may implement IBL in the classroom without knowing”. Also, there was a discrepancy between teachers’ own definition of IBL and the activities that they claimed to be used in the classroom. For example, 41% of teachers provided different perspectives about IBL in the third interview question about IBL activities in the classrooms. By contrast, only around a quarter of teachers (26%) mentioned similar aspects of IBL in both first and third interview questions. These findings support the conclusion that most participants did not have a clear understanding of IBL. Table 5.18 below presents the differences between teachers’ answers in the first and third interview questions.

Table 5. 18. The differences between teachers' answers in the first and third interview questions

Teachers who matched their answers	Teachers who provided additional aspects of IBL	Teachers who provided different aspects of IBL
T1, T2, T14, T21, T23, T26, T28	T3, T5, T6, T7, T8, T10, T11, T22, T24	T4, T9, T12, T13, T15, T17, T18, T19, T20, T25, T27
26%	33%	41%

In the interview, 59% of the teachers suggested activities that were all related to the adopted IBL definition in their answers to the question 'what type of teaching practices (activities) take place when using IBL?'. 26% of the interviewed teachers provided a mix of activities, some that are and some that are not related to IBL according to the adopted definition. The remaining 15% of the interviewed teachers identified activities that are not related to the adopted IBL definition. Therefore, at least 41% of the interviewees could not definitively identify IBL-consistent teaching activities when asked to do so.

All four teachers who were categorised as having good knowledge in their IBL definition also suggested activities that were all related to the adopted IBL definition in their descriptions of IBL activities. This result was most revealing because none of those teachers who were categorised as having good knowledge in their IBL definition suggested any activities that are not related to IBL. This finding supports the conclusion that this subset of teachers has a sound understanding of IBL in practice. Furthermore, none of the teachers who were classified as having merely fair knowledge about IBL provided only unrelated activities to the adopted IBL definition, although two of them (40%), alongside four (27%) of those with only basic knowledge in their IBL definition, suggested a mix of activities that included some not related to IBL. This finding indicates that those subsets of teachers with weaker knowledge of the IBL definition appeared to have a corresponding lack of clear understanding about IBL activities according to the adopted definition of IBL.

With regard to the two teachers who were classified as having uncertain knowledge in their IBL definition, one of them provided completely unrelated activities, in comparison to the adopted IBL definition, whereas the other provided a mix of activities that are and are not related to the adopted IBL definition. As might be expected the teacher who was classified as having no knowledge in the definition of IBL also provided unrelated IBL activities. These findings support the conclusion that those subsets of teachers appeared to have a lack of understanding about IBL in practice. In other words, there is a link between conceptual understanding of IBL and pedagogical thinking about IBL-based teaching. Table 5.19 below shows a comparison between teachers' classifications of IBL definition and IBL activities.

Table 5. 19. A comparison between teachers' answers to IBL definition and IBL activities

Teachers' classifications based on their answers to the question 'how do you define IBL?' (N=27)		Teachers' classifications based on their answers to the question 'what type of teaching practices (activities) take place when using IBL?' (N=27)		
		Teachers who provided in-class activities that are all related to the adopted IBL definition (%)	Teachers who provided in-class activities both related and unrelated to the adopted IBL definition (%)	Teachers who provided in-class activities that were all unrelated to the adopted IBL definition (%)
		16 (59%)	7 (26%)	4 (15%)
No knowledge	1 (4%)			1 (100%)*
Uncertain knowledge	2 (7%)		1 (50%)	1 (50%)
Basic knowledge	15 (56%)	9 (60%)	4 (27%)	2 (13%)
Fair knowledge	5 (18%)	3 (60%)	2 (40%)	
Good knowledge	4 (15%)	4 (100%)		

*The %s in the cross-tabulation are row %s, not column %s.

5.2.8. Teachers' Perceptions About the Role of Teachers and Students in IBL

Teachers were asked in the interviews about their views on the role of the teacher and students in IBL. Table 5.20 below presents the exact terms that were used by teachers in responding to the question 'in inquiry-based learning, what is your role as a teacher?'.

Table 5. 20**.** Terms in the answers to the teacher's role in IBL

Terms in the answers to teacher's role in IBL	**Teachers responding**	**Frequency**
Guide	T1, T2, T3, T5, T7, T8, T9, T11, T13, T15, T18, T20, T21, T22, T23, T24, T27	17 (63%)
Corrector	T6, T10, T11, T17, T20, T27, T28	7 (26%)
Supervisor	T1, T2, T14, T15, T18, T19	6 (22%)
Facilitator	T1, T13, T24, T28	4 (15%)
Organiser	T4, T19	2 (7%)
Motivator	T6, T14	2 (7%)
Leader	T4	1 (3%)
Extract information from students	T12	1 (3%)
Assistant	T21	1 (3%)
Provider of information	T22	1 (3%)
Ask questions	T25	1 (3%)
Present a Video	T25	1 (3%)
Formulate a problem	T26	1 (3%)

As can be seen from table 5.20 above, teachers used different terms to express their views about the role of the teacher in IBL. Some of these terms could be grouped into one category because it seems that they lead to a similar meaning, and the differences in terms may be due to linguistic expressions of participants. For example, the terms 'guide', 'facilitator' and 'supervisor' were often used interchangeably by the same teacher as shown in table 5.20. However, some teachers clarified what they mean by the terms 'guide' or 'facilitator'. For example, T3 explained his role as a guide when he stated that:

> The role of the teacher in IBL is a guide, where the teacher provides inquiry to the student, and then I see the information that the student has reached, then I clarify that information, if the student reached the correct information that is good, if he reached incomplete information, I complete this information.

In T3's case, he provides students with a question because he defined IBL as posing questions. So, he tries to guide students in answering questions in the way he mentioned in this statement.

In another example, T13 indicated that:

> The role of the teacher is a guide or facilitator, I listen to the student and try to guide him in order to keep him focused because the primary students are very easy to lose their concentration.

In general, it seems that almost all teachers agreed that IBL is a learner-centred approach where the students become more responsible for the learning process, while the teacher adopts a role similar to being a facilitator or guide. This result was not completely surprising for the reason that in the last ten years there has been a considerable emphasis on this aspect of IBL in Saudi Arabia. Therefore, teachers' views may be indirectly affected by the MOE's guidance and instruction. However, the expressed views of the teachers about IBL and their actual modes of teaching remain intriguing.

5.2.9. Summary of the Qualitative Findings Related to Teachers' Understandings of IBL

In summary, the findings of the interviews and the online questionnaires about teachers' understandings of IBL reveal that in general there was no consensus on a specific definition or characteristic of IBL among science teachers. However, some teachers shared common ideas about IBL such as finding things out. In addition, most of the participants either have a broad understanding of the concept of IBL as research, discovery, and learner-centred, or a partial picture of IBL compared to what is proposed from NRC (2000), such as questions and observations. Only 15% of the interview sample and 11% of the questionnaire sample mentioned at least three characteristics of IBL. These findings indicate that teachers in general lack a full understanding of IBL that is congruent with the understanding inherent in the Saudi policy. Furthermore, the findings suggest that the nature of school level, teaching experience, and specialisation may each play a role in teachers' understanding of IBL.

5.3. Quantitative Findings Related to Teachers' Understandings of IBL

This section was intended to reveal teachers' understandings of IBL from the survey questionnaire data. As indicated in the methodology chapter (section 4.4.3.1), teachers were provided with items that included IBL activities as defined by NRC (2000) and some non-IBL activities and they were asked to express their agreement with each statement on a five-point Likert scale ranging from strongly agree to strongly disagree. In order to calculate the mean values of each item, the five-point Likert scale from strongly agree to strongly disagree was mapped into numerical values of (5, 4, 3, 2, and 1 respectively).

Table 5.21 below presents the findings of the questionnaire related to closed-ended questions about teachers' understandings of IBL.

Table 5. 21. The percentage, frequency, and mean of science teacher responses to the scale of teachers' understandings of IBL in the questionnaire

Does inquiry-based learning involve the following activities?	**Strongly agree**		**Agree**		**Neither agree nor disagree**		**Disagree**		**Strongly disagree**		**Mean**
	Percentage	N	Percentage	N	Percentage	N	Percentage	N	Percentage	N	
Engaging students in problem solving activities	62%	178	34%	99	3%	7	1%	4	0%	0	4.57
Students formulate explanations from evidence	49%	142	46%	133	4%	10	0.35%	1	0.65%	2	4.43
Students use tools to gather, analyse, and interpret data	51%	146	42%	122	5%	15	1%	4	0.35%	1	4.42
Students research what is known	52%	149	38%	110	7%	21	2%	5	1%	3	4.38
Students propose answers	48%	138	45%	129	5%	15	2%	5	0.35%	1	4.38
Students communicate and justify explanations	47%	137	44%	126	7%	19	1%	3	1%	3	4.36
Students formulate hypotheses	47%	135	42%	123	8%	23	2%	5	0.69%	2	4.33
Students ask questions	46%	133	44%	127	6%	16	4%	12	0%	0	4.32
Students plan and carry out investigations	45%	131	41%	118	11%	31	3%	8	0%	0	4.29
Students engaging in activities with predetermined outcomes	34%	98	39%	112	14%	40	9%	27	4%	11	3.90
Students listen to the teachers lecture and receive information from them	23%	67	24%	70	17%	50	19%	53	17%	48	3.19

Note: the non-inquiry activities are in italic

The statistical analysis shows that most of the participants either strongly agree or agree with all statements about the IBL activities in table 5.21. Also, the highest mean of 4.57 was related to the statement of 'engaging students in problem solving activities'. By contrast, the lowest mean of 3.19 was related to a non-inquiry activity statement which is 'students listen to the teachers lecture and receive information from them'. This finding revealed that teachers would map non-inquiry activities to inquiry activities. For example, nearly half of the teachers either strongly agreed or agreed to the non-inquiry activity statement of 'students listen to the teachers lecture and receive information from them'. Also, 73% of participants either strongly agreed or agreed to the non-inquiry activity statement of 'students engaging in activities with predetermined outcomes'. In addition, table 5.21 shows that only a minority of participants disagreed or strongly disagreed with the two non-inquiry activity statements. Thus, it seems that teachers may find it difficult to distinguish some non-inquiry activities from activities that are characteristic of inquiry.

Another indication that the participants were confused about the meaning of IBL is that only 11% of the questionnaire sample were able to correctly recognise all inquiry and non-inquiry activities. This result indicated the potential ambiguity of the understanding of the IBL among the participants because the majority of the teachers were unable to distinguish between the activities that were and were not related to IBL.

There are some notable differences between the interview and questionnaire data. Although almost all the surveyed teachers either agreed or strongly agreed with the activities of IBL in table 5.21, some of these activities were not indicated or were only rarely mentioned by the teachers in interviews or in the open-ended question in the questionnaire. For example, by comparing the result of the table 5.21 to the interview findings of IBL activities in the table 5.17 it could be noted that none of the participants who were interviewed mentioned problem-solving activities when they were asked about the activities used when implementing IBL in the classroom. However, the results in table 5.21 suggest that the majority of teachers strongly agreed that IBL involved problem solving activities: the highest mean of 4.57 was related to the statement of 'engaging students in problem solving activities'. Also, when teachers were asked to provide their own definition of IBL in the interviews and the survey questionnaire, a minority of participants indicated problem solving as an aspect of IBL. In another example, almost all teachers (95%) either strongly agreed or agreed to the statement of 'students formulate explanations from evidence' as an IBL activity. However, none of the participants mentioned this aspect in the qualitative data. Table 5.21 also confirms some common understandings of IBL from the qualitative data that include: searching what is already known, asking questions, and carrying out investigations. The next section discusses the differences between different groups in their responses to the questions about teachers' understandings of IBL in the questionnaire.

5.3.1. Differences in Teachers' Understandings of IBL According to Their Gender, Teaching school level, Teaching experience, and Specialisation

In order to determine whether there were statistically significant differences between sub-groups on the scale of teachers' understandings of IBL or not, some statistical tests were performed. As indicated in the methodology chapter (section 4.4.3), the level of teachers' understanding of IBL was measured on five-point ordinal scales ranging from

‘Strongly Agree’ (5) to ‘Strongly Disagree’ (1). The mean scores of the answers to 11 items were calculated for each respondent. As explained in section 4.6.3, the data from the teachers’ answers to Likert scale items were not normally distributed, therefore, nonparametric tests were used. Mann–Whitney U tests and Kruskal–Wallis tests were performed to check if there were statistically significant differences in the mean scores of teachers’ understandings of IBL among different groups.

Gender: In order to compare between teachers’ gender, a Mann–Whitney U test was used. Table 5.22 shows the results of the comparison using the Mann-Whitney U test.

Table 5. 22. Results of the Mann-Whitney U test on gender related to the scale of teachers’ understandings of IBL in the questionnaire

Domain	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Asymp. Sig. (2-tailed)
Teachers’ understandings of IBL	Male	139	137.63	19131.00	9401.000	.176
	Female	149	150.91	22485.00		
	Total	288				

As can be noticed from the result of the Mann–Whitney U test above, there was no statistically significant difference between male and female teachers in their understandings of IBL - the 2-tailed test had a p value greater than 0.05.

Teaching school levels: The Kruskal-Wallis test was conducted to examine the differences in mean scores of teachers’ understanding of IBL between the three teaching levels (primary, middle, and high). Table 5.23 shows the results of the comparison using the Kruskal-Wallis test.

Table 5. 23. Results of the Kruskal-Wallis test on teaching school level related to the scale of teachers' understandings of IBL in the questionnaire

Domain	Teaching level	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' understandings of IBL	Primary	85	118.04	12.358	2	.002
	Middle	77	158.22			
	High	126	153.97			
	Total	288				

The result of the Kruskal-Wallis test showed that there was a significant difference (p=0.002) between the mean ranks of at least one pair of groups in teachers' understandings of IBL based on teaching levels. To specify where the differences between the groups lie, Dunn's pairwise tests were carried out for all the three pairs of groups. There was strong evidence (p=.002) of a difference between the group of primary school teachers and high school teachers. The mean rank of teachers' understandings of IBL for primary school teachers was 118.04 compared to 153.97 for the group of high school teachers. Furthermore, there was also strong evidence (p=0.002) of a difference between the group of primary school teachers and middle school teachers. The mean rank of teachers' understandings of IBL for primary school teachers was 118.04 compared to 158.22 for the group of middle school teachers. However, there was no evidence of a difference between middle and high school teachers in their understandings of IBL. These findings indicate that the primary school teachers' understandings of IBL are different from middle and high school teachers.

Teaching experience: The Kruskal-Wallis test was also performed to examine the differences in the mean scores of teachers' understanding of IBL according to their teaching experience. Table 5.24 below shows the results of the comparison using the Kruskal-Wallis test.

Table 5. 24. Results of the Kruskal-Wallis test on teaching experience related to the scale of teachers' understandings of IBL in the questionnaire

Domain	Experience	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' understandings of IBL	0-1	12	150.92	7.314	5	.198
	2-5 Years	51	139.03			
	6-10 Years	81	133.14			
	11-15 Years	49	165.82			
	16-20 Years	43	159.45			
	Over 20 years	52	133.63			
	Total	288				

The result of the Kruskal-Wallis test showed that there was no statistically significant difference ($p > 0.05$) in teachers' understandings of IBL based on their teaching experience.

Specialisation: The Kruskal-Wallis test was performed to examine the differences in mean scores of teachers' understandings of IBL between different specialisations. Table 5.25 shows the results of the comparison using the Kruskal-Wallis test.

Table 5. 25. Results of the Kruskal-Wallis test on specialisation related to the scale of teachers' understandings of IBL in the questionnaire

Domain	Specialisation	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' understandings of IBL	Physics	60	153.23	6.168	4	.187
	Chemistry	67	152.58			
	Biology	91	146.91			
	General science	29	112.28			
	Other	41	135.96			
	Total	288				

The result of the Kruskal-Wallis test also showed that there was no statistically significant difference ($p > 0.05$) in teachers' understandings of IBL based on the teachers' specialisations.

5.4. Summary of the Chapter

This chapter addressed the findings related to the first research question which is about teachers' understandings of IBL. The qualitative findings indicate that in general most of the teachers appeared to have either lacking or basic knowledge of IBL as defined by NRC (2000) while the minority of participants seemed to have a good knowledge of IBL. In addition, the understanding of IBL as it related to researching, deducing, discovering, posing questions, carrying out experiments, making observations, and extracting prior knowledge were frequently reported by the participants. Also, the quantitative findings reveal that even though most teachers either agreed or strongly agreed with all statements about IBL activities as suggested by NRC (2000), they also mapped non-inquiry activities to inquiry activities. The next chapter addresses findings related to the second research question which is about teachers' beliefs about IBL.

Chapter 6: Analysis and Findings of Teachers' Beliefs About IBL

6.1. Introduction

The previous chapter presented the findings related to the first research question which was 'how do Saudi science teachers understand inquiry-based learning?'. The aim of this chapter is to introduce the results of the second research question which was 'what are Saudi science teachers' beliefs about inquiry-based learning?'. In doing so, it presents teachers' views about whether IBL is important and beneficial in teaching science. In order to answer the second research question, data were collected from interviews and online questionnaires. This chapter is organised into three sections. The first section presents the interview findings, and the second section shows the questionnaire findings. The third section summarises the analysis and findings presented in this chapter.

6.2. Interview Findings Related to Teachers' Beliefs About IBL

As shown in the previous chapter, teachers hold different conceptions of IBL, and for this reason or others, teachers could have different opinions about IBL. So, there was a need to identify a precise meaning of IBL in order to allow meaningful comparison of teachers' views of IBL according to a common definition. Therefore, before asking teachers about their beliefs of IBL, the definition of IBL as suggested by NRC (2000) was printed out and presented to them. The definition is:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light

> of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (NRC, 2000, p. 23)

Teachers were then asked to express their opinions about the NRC's (2000) definition of IBL. The findings revealed that almost all teachers agreed that the NRC's definition of IBL is an appropriate and comprehensive definition. For example, T1 commented that "it is a comprehensive definition which covers all aspects". Similarly, T11 reflected that "everything about IBL is included in this definition". Correspondingly, T22 stated that "this definition is excellent and comprehensive, and it includes the steps of scientific research". So, these findings suggest that the teachers who were interviewed held a positive attitude towards NRC's definition of IBL – they felt it to be a fair definition. That may be because the NRC's definition of IBL includes various learning activities, so they considered it comprehensive. Also, the current science textbooks in Saudi Arabia were developed in the light of NRC (refer to the study context chapter for more details), therefore some teachers might be aware of these aspects as T17 indicated that "it is exactly what we have in the biology textbook 1 (grade 10)".

In the interviews, teachers were asked about the importance of using IBL in teaching science according to NRC's definition of IBL. Interestingly, all teachers agreed that IBL, as defined by NRC (2000), is important and effective in teaching science. However, they indicated a range of reasons that may justify their positive attitude toward IBL. The thematic analysis of the interviews allowed the researcher to drew out four themes: IBL enhances students' understanding; IBL promotes self-directed learning; IBL develops students' abilities and skills; IBL enhances psychological factors related to learning (table 6.1 shows the frequencies of the extracted themes).

Table 6. 1. The main themes extracted from the interviews related to teachers' beliefs about IBL

Teachers' beliefs about IBL	Teachers responding	Frequency (N=27)
IBL enhances students' understanding	T2, T5, T7, T17, T18, T20, T22, T26, T27, T28	10
IBL promotes self-directed learning	T1, T4, T8, T12, T20, T22, T25	7
IBL develops students' abilities and skills	T1, T9, T17, T25	4
IBL enhances psychological factors related to learning	T4, T14, T23	3

6.2.1. IBL Enhances Students Understanding

10 (out of 27) teachers who were interviewed reflected that IBL enhances students' understanding. They indicated many reasons for such a view. For example, T2 associated IBL with deep understanding when he commented:

> IBL is important because if the students practise something it will be more established in their mind, whenever they practise science activities such as observation and posing questions, the information will be more established.

In another example, T17 related IBL to students' beliefs of the scientific concepts. T17 commented that "IBL is very important because 50% of what I teach the students can see it by their eyes, as a result, they believe it".

T5, T20, T22, T26, and T28 thought that there is a positive association between IBL and students' achievement. For instance, T5 reported his experience with implementing IBL, and he found that students learn better by IBL than traditional teaching as quoted below:

> I tried IBL many times last term and I found that students' achievement is better than the term before when I have used the traditional method of teaching. If the students research for information by themselves, they will understand more.

By the same way, T20 indicated that "sometimes I ask students to find answers and I feel that they understand better, and sometimes when the students learn from their classmates, they will realise more than my explanation". So, it appears that those 10 teachers are in support of the idea that IBL enhances students' understanding.

6.2.2. IBL Promotes Self-Directed Learning

One theme that is apparent in the interview data is that some teachers believe that IBL promotes self-directed learning where students are independent and self-reliant. Based on the interview data, some teachers think that IBL helps students to formulate their own knowledge and take ownership of their learning. This finding can be supported by several statements. For example, T4 commented that "the benefit of IBL is that the student makes a conclusion". In addition, T8 said: "IBL is effective in teaching science because it allows students to formulate their own knowledge". Likewise, T12 reflected that: ''IBL is effective in terms of the knowledge is constructed by students''. T22 also emphasized that "IBL makes students depend on themselves". In the same way, T25 felt that "IBL makes the lesson based on students". It seems that the above-mentioned opinions of the teachers are in support of the idea that IBL makes students actively participate in the learning process and helps them to construct their knowledge.

6.2.3. Teaching by IBL Develops Students' Abilities and Skills

Based on teachers' responses, there were some teachers who believed that IBL helps students to develop their own abilities and skills in different areas such as research and thinking. To illustrate, T19 claimed that "IBL develops students' ability in researching, instead of passively receiving information from the teacher, the student becomes a seeker of knowledge". In another example, T17 proposed that IBL develops questioning skills as he mentioned in the interview that "IBL is very important because students start formulating questions". In addition, some teachers reported that IBL improves students' thinking skills. For example, T1 reflected that IBL has the ability to engage students in higher order thinking skills as he expressed that:

> IBL is important because when the student makes an investigation by his own or with a classmate, he begins to think critically and uses the higher order thinking, instead of using the lower-order thinking (e.g., understanding, remembering, and memorising), he implements the higher thinking skills (e.g., applying, analysing, and evaluating). This is the merit of IBL.

Unlike T1, T9 reported lower order thinking skills as he commented that "IBL stimulates students' thinking which makes them remember or recall the prior information". T9 here appeared to have focused on a basic level of thinking, while T1 highlighted more complex thinking level skills such as analysing and evaluation. Another teacher, T25, reported that

“IBL promotes students’ thinking”, but T25 did not specify a particular type of thinking that could indicate the depth of thinking skills.

6.2.4. IBL Enhances Psychological Factors Related to Learning

In the interviews, three teachers reported that IBL could positively influence some psychological factors of students such as interest and motivation. For instance, T4 commented that:

> The benefit of IBL is that the student makes a conclusion at this time where massive technology innovation is going on. Unfortunately, many communities or students are not interested in what benefits them in their educational journey, but they are shifting toward games. So, it is an opportunity for teachers to practise such a strategy in order to make students feel a sense of happiness when they reach a result.

Based on this quotation, it seems that T4 feels IBL is important because students enjoy practising and solving a task. In another example, T6 stated that “IBL is usually effective because it contains various activities which keep me and my students active and away from boredom”. Likewise, T14 reported that “IBL is effective because it includes many activities, therefore it makes students excited”. T23 indicated three advantages of using IBL as follows: “IBL is very effective and important because it stimulates students to research, raises students’ attention, and increases students’ motivation to learn”. A common idea between these three teachers (T6, T14, and T23) is that IBL increases students’ interest and engagement in learning science.

6.2.5. Teachers' Beliefs About the Suitability of IBL for Their Students

During the interviews, teachers were asked whether IBL is suitable for their students or not. The majority of the teachers agreed that IBL is suitable for their students. However, four of the teachers indicated that IBL is suitable for students if certain conditions are met such as a manageable number of students and availability of resources. Also, another three teachers reflected that IBL is suitable for most lessons but not all lessons, while one teacher commented "somewhat". Only three teachers reported that IBL is difficult or not suitable for their students. Table 6.2 below shows teachers' responses to the question 'do you think IBL is suitable for your students?'.

Table 6. 2**.** Teachers' responses to the question 'do you think IBL is suitable for your students?'

Response	**Teachers responding**	**Frequency (N=27)**
Yes	T7, T8, T9, T18, T20, T21, T22, T23, T24, T25, T26, T28	12
Yes, with condition	T11, T13, T17, T19, T27	5
Difficult or No	T2, T5, T15	3
In most lessons	T1, T3, T12	3
Somewhat	T14	1

In general, the findings in table 6.2. revealed that most teachers who were interviewed agreed that IBL is suitable and appropriate for their students. Some teachers who felt that IBL is not suitable for their students felt this to be the case because they believe that their school environment is inappropriate for IBL and does not have sufficient resources. This study explored the obstacles to implementing IBL, from the teachers' point of view, and this will be presented in Chapter 8.

6.3. Online Questionnaire Findings Related to Teachers' Beliefs About IBL

The participants were provided with statements about the potential importance and benefits of IBL to measure the level of participants' agreement to these statements. The statements of this section of the questionnaire were developed based on the MOE Saudi teacher's guidance as described in Chapter 4. The findings of the questionnaire related to teachers' beliefs about IBL are presented in table 6.3 below.

Table 6. 3. The percentage, frequency, and mean of science teacher responses to the scale of teachers' beliefs about IBL in the questionnaire

To what extent do you agree with the following statements	Strongly agree		Agree		Neither agree nor disagree		Disagree		Strongly disagree		Mean
	%	N	%	N	%	N	%	N	%	N	
IBL is important for teaching science	53%	152	39%	112	7%	21	0%	0	1%	3	4.42
Teaching by inquiry helps students to understand of scientific concepts	50%	144	45%	130	3%	9	2%	5	0%	0	4.43
Teaching by inquiry develops students' abilities and skills	58%	167	37%	107	4%	11	1%	3	0%	0	4.52
Teaching by inquiry develops problem-solving skills	61%	174	34%	99	4%	12	1%	3	0%	0	4.54
Teaching by inquiry develops critical thinking skills	59%	170	36%	103	4%	11	1%	4	0%	0	4.52
IBL helps students to formulate their own knowledge	58%	166	39%	113	2%	7	0.35%	1	0.35%	1	4.53
IBL encourages students to discover, formulate questions and hypotheses	63%	182	33%	94	3%	9	1%	3	0%	0	4.58
IBL activities enhance and expand the learning process	55%	158	38%	110	6%	17	0.65%	2	0.35%	1	4.47
IBL gives priority to students to learn and practise the processes of science	57%	164	39%	111	3%	10	1%	3	0%	0	4.51
IBL makes students actively participate in the learning process	53%	153	41%	119	4%	11	1%	4	0.35%	1	4.45
IBL links science to students' lives and experiences	57%	165	38%	110	3%	9	1%	3	0.35%	1	4.51
Average mean											4.50

As can be seen from the table 6.3 above, the average mean was 4.50 out of 5 which could indicate that the participating science teachers had a highly positive attitude towards IBL and its potential importance and benefits in teaching science. The majority of participants either strongly agreed or agreed with all statements in table 6.3. While a high proportion of participants selected the strongly agree option, few participants chose either disagree or strongly disagree options. This finding suggests that in general the science teachers in Saudi Arabia have an acceptance of the idea of IBL.

6.3.1. Differences in Teachers' Beliefs About IBL According to Their Gender, Teaching School Level, Teaching Experience, and Specialisation

Gender: In order to compare between gender in their beliefs about IBL, a Mann-Whitney U test was used. The comparison was done between teachers' mean scores across the 11 questions in table 6.3 above. Table 6.4. below shows the results of the comparison using the Mann-Whitney U test.

Table 6. 4. Results of the Mann-Whitney U test on gender related to the scale of teachers' beliefs about IBL in the questionnaire

Domain	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Asymp. Sig. (2-tailed)
Teachers' beliefs about IBL	Male	139	142.05	19744.50	10014.500	.622
	Female	149	146.79	21871.50		
	Total	288				

As can be noticed from the result of the Mann–Whitney U test above, there was no statistically significant difference between male and female science teachers in their beliefs about IBL - the 2-tailed test had a p value greater than 0.05.

Teaching school levels: The Kruskal-Wallis test was conducted to examine the differences in teachers' beliefs about IBL according to the teaching levels (primary, middle, and high). Table 6.5 shows the results of the comparison using the Kruskal-Wallis test.

Table 6. 5. Results of the Kruskal-Wallis test on teaching school level related to the scale of teachers' beliefs about IBL in the questionnaire

Domain	Teaching level	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' beliefs about IBL	Primary	85	123.38	10.292	2	.006
	Middle	77	164.28			
	High	126	146.66			
	Total	288				

The result of the Kruskal-Wallis test showed that there was a strong significant difference ($p=0.006$) between the mean ranks of at least one pair of groups in teachers' beliefs about IBL based on the teaching levels. As shown in table 6.5, the highest mean rank was 164.28 for middle school teachers while the lowest mean rank was 123.38 for primary school teachers. These findings indicate that middle school teachers were more likely to hold a positive attitude towards IBL than the primary and high school teachers. In contrast, primary school teachers were less likely to hold a positive attitude towards IBL than the middle and high school teachers.

To specify where the differences between the groups lie, Dunn's pairwise tests were carried out for the three pairs of groups. There was strong evidence ($p=.001$) of a significant difference between the group of primary school teachers and middle school teachers. The mean rank of teachers' beliefs about IBL for primary school teachers was 123.38 compared to 164.28 for the group of middle school teachers. Furthermore, there was evidence (p=0.042) of a significant difference between the group of primary school teachers and high school teachers. The mean rank of teachers' beliefs about IBL for primary school teachers was 123.38 compared to 146.66 for the group of high school teachers. There was no evidence of a difference between middle and high school teachers in their beliefs about IBL. These findings indicate that primary school teachers are less positive about IBL than middle and high school teachers.

Teaching experience: The Kruskal-Wallis test was also performed to examine the differences in teachers' beliefs about IBL according to teaching experience. Table 6.6 shows the results of the comparison using the Kruskal-Wallis test.

Table 6. 6. Results of the Kruskal-Wallis test on teaching experience related to the scale of teachers' beliefs about IBL in the questionnaire

Domain	Experience	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' beliefs about IBL	0-1	12	142.08	8.059	5	.153
	2-5 Years	51	141.39			
	6-10 Years	81	126.28			
	11-15 Years	49	165.81			
	16-20 Years	43	150.40			
	Over 20 years	52	151.53			
	Total	288				

The result of the Kruskal-Wallis test showed that there was no statistically significant difference in teachers' beliefs about IBL based on teaching experience.

Specialisation: The Kruskal-Wallis test was performed to examine the differences in teachers' beliefs about IBL between different specialisations. Table 6.7 shows the results of the comparison using the Kruskal-Wallis test.

Table 6. 7. Results of the Kruskal-Wallis test on specialisation related to the scale of teachers' beliefs about IBL in the questionnaire

Domain	Specialisation	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' beliefs about IBL	Physics	60	134.89	14.394	4	.006
	Chemistry	67	171.81			
	Biology	91	148.79			
	General science	29	119.09			
	Other	41	122.38			
	Total	288				

The result of the Kruskal-Wallis test showed that there was a statistically significant difference (p=0.006) between specialisation groups in their beliefs about IBL. As shown in table 6.7, the highest mean rank was 171.81 for chemistry teachers while the lowest mean rank was 119.09 for the teachers who are specialists in general science.

To specify where the differences between the groups lie, Dunn's pairwise tests were carried out on each pair of groups. There was strong evidence (p=0.004) of a difference between the group of the teachers who were specialists in chemistry and those who were specialists in general science. The mean rank of teachers' beliefs about IBL for the chemistry group was 171.81 compared to 119.09 for the general science group. Furthermore, there was strong evidence (p=0.002) of a difference between the group of the teachers who were specialists in chemistry and those who were non-science specialists (the "other" group). The mean rank of teachers' beliefs about IBL for the chemistry group was 171.81 compared to 122.38 for the "other" group. Additionally, there was evidence (p=0.011) of a difference between teachers who were specialists in physics and those who were specialists in chemistry. The mean rank of teachers' beliefs about IBL for the physics group was 134.89 compared to 171.81 for the chemistry group. On the other hand, there was no evidence of a difference between the other pairs. These findings indicate that teachers who are specialists in chemistry were more likely to hold a positive attitude towards IBL than the other group of specialisations. In contrast, teachers who are specialists in general science were less likely to hold a positive attitude towards IBL than the other group of specialisations.

6.4. The Relationship Between Teachers' Understandings and Beliefs About IBL

Because the data on teachers' answers to Likert scale items in the questionnaire were not normally distributed, Spearman's rho correlation coefficient (r_s) was calculated to assess the relationship between teachers' understandings and their beliefs about IBL. Table 6.8 below shows the results of the Spearman's rho correlation regarding teachers' understandings and beliefs about IBL.

Table 6. 8. The correlation matrix for teachers' understandings and beliefs about IBL

			Teachers' beliefs about IBL
Spearman's rho	Teachers' understandings of IBL	Correlation Coefficient	.634**
		Sig. (2-tailed)	.000
		N	288

**. Correlation is significant at the 0.01 level (2-tailed).

Cohen (1992) provides guidelines for interpretation of a correlation coefficient (*r*) as follows: a correlation coefficient of .1 to .3 is considered a weak or small association; a correlation coefficient of .3 to .5 is considered a moderate correlation; a correlation coefficient of .5 to .9 represents a strong correlation; a correlation coefficient of .9 to 1.0

is classified as a very strong correlation. As shown in table 6.8, the results of the Spearman's rho correlation indicated that there was a strong positive association between teachers' understandings and beliefs about IBL, $r_s = .634$, $p < .001$, $N = 288$. Although most of the teachers expressed positive views about IBL, greater positivity is associated with more accurate understanding of the nature of IBL, and vice versa, amongst this group of teachers.

6.5. Summary of the Chapter

This chapter presented the findings related to the second research question regarding teachers' beliefs about IBL. The data were collected from interviews and online questionnaires. The interview results revealed that almost all teachers tended to belief that IBL, as defined by NRC (2000), is an important and effective way of teaching science. The interview responses yielded evidence that the most reported perceived advantages of using IBL were: enhancing students' understanding, promoting self-directed learning, and developing students' abilities and skills. In addition, the online questionnaire findings confirmed the results of the interviews which indicate that the participants held a high positive attitude toward the importance and benefits of IBL in teaching science. The next chapter presents the findings related to the third research question which is about teachers' implementation of IBL.

Chapter 7: Analysis and Findings of Teachers' Implementation of IBL

7.1. Introduction

This chapter is intended to present the findings related to the third research question which was 'how do Saudi science teachers implement inquiry-based learning in the classroom?'. Data were collected from three sources: classroom observations, semi-structured interviews, and an online questionnaire. Descriptive statistics, including frequencies and percentages, were conducted to present the findings. The remainder of the chapter is organised into five sections. The first section presents the findings of the classroom observation as it was the first stage of data collection. It is followed by findings regarding the relationship between teachers' knowledge of IBL and their classroom practices. The third section addresses the interview findings, and the fourth section outlines the results of the online questionnaire related to teachers' implementation of IBL. The fifth and final section summarises the analysis and findings presented in this chapter.

7.2. Classroom Observation Findings Related to Teachers' Implementation of IBL

The first stage of data collection was classroom observations. 45 science lessons were observed across different school levels. As indicated in the methodology chapter, section 4.4.1, the "Science Teacher Inquiry Rubric (STIR)" was used to rate teachers' practice of IBL in the classroom. The STIR instrument evaluates six categories based upon the essential features of classroom inquiry defined by the NRC (2000). The six categories, based on the NRC features, are:

1. Teacher provides an opportunity for learners to engage with a scientifically oriented question.
2. Teacher engages learners in planning investigations to gather evidence in response to questions.
3. Teacher helps learners give priority to evidence which allows them to draw conclusions and/ or develop and evaluate explanations that address scientifically oriented questions.
4. Learners formulate conclusions and/or explanations from evidence to address scientifically oriented questions.
5. Learners evaluate their conclusions and/or explanations in light of alternative conclusions/ explanations, particularly those reflecting scientific understanding.
6. Learners communicate and justify their proposed conclusions and/or explanations. (Bodzin & Beerer, 2003, pp. 43-44)

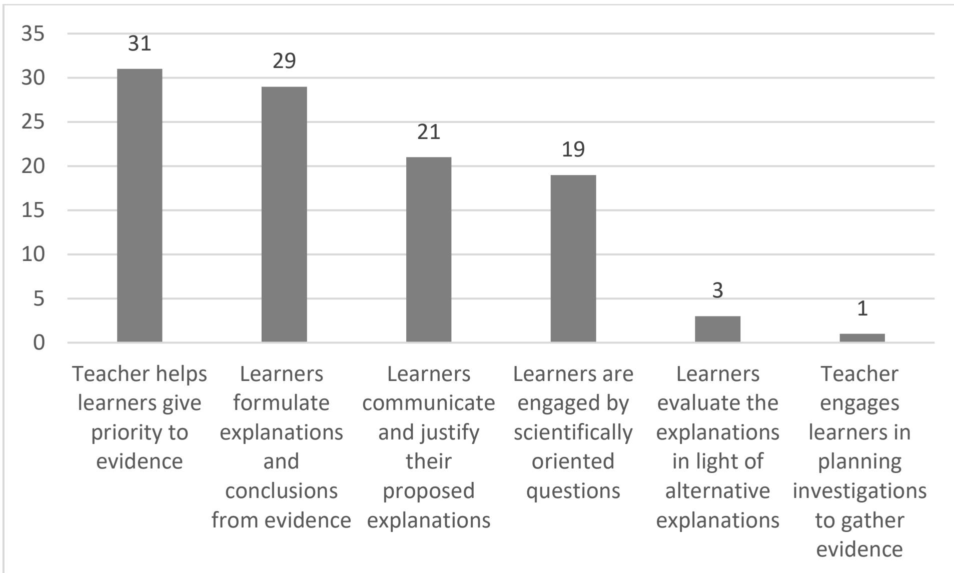
Each category in the STIR instrument contains five sub-measures aligned with the NRC (2000) definition of the essential features of classroom inquiry. Each category of the STIR instrument was ranked on a scale of 0-4 with 0 indicating that the inquiry feature was not presented and 4 being the most student-directed form of IBL while 1 being the most teacher-directed form of IBL (see appendix A.1 for STIR instrument). The overall mean score of each feature of inquiry presented in the classrooms was calculated, in order to quantify the direction of IBL. Table 7.1 below presents the frequency and mean score of each feature of inquiry in the STIR instrument.

Table 7. 1. The frequency and mean of each feature of inquiry in STIR instrument

Inquiry feature	Frequency (out of 45)	Mean (out of 4)
Learners are engaged by scientifically oriented questions	19	1.00
Teacher engages learners in planning investigations	1	1.00
Teacher helps learners give priority to evidence	31	1.61
Learners formulate conclusions and/or explanations from evidence	29	1.93
Learners evaluate the explanations in light of alternative explanations	3	1.00
Learners communicate and justify their proposed explanations	21	1.09

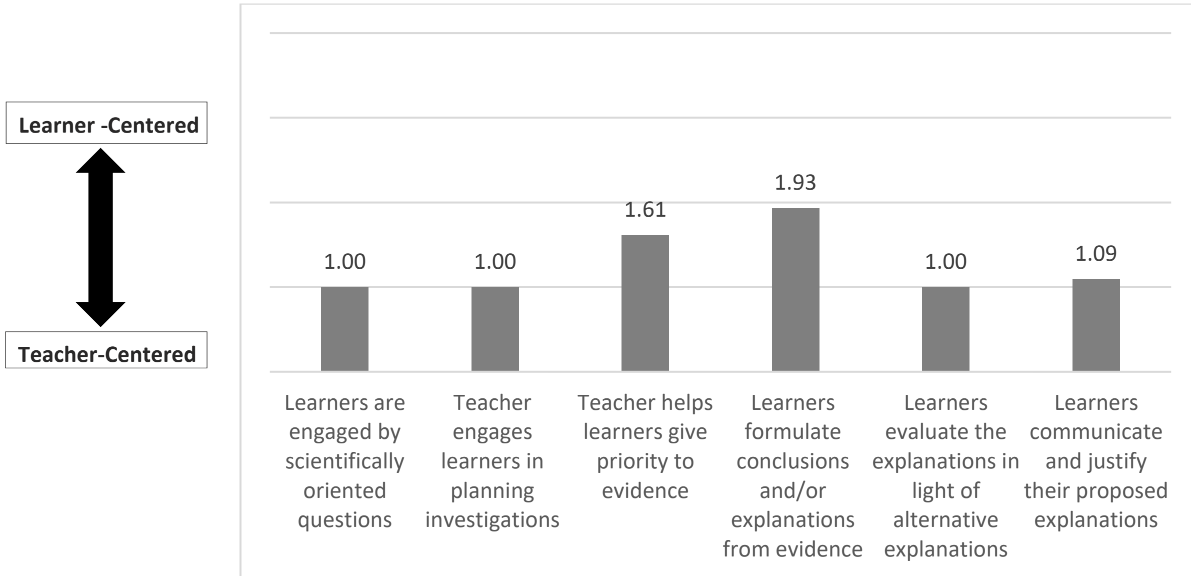
As can be noticed from table 7.1 above the feature ‘teacher helps learners give priority to evidence’ was the most frequent inquiry feature recorded in the observed lessons which was observed in 31 science lessons. In addition, the second most frequent feature that was observed was ‘learners formulate conclusions and/or explanations from evidence’ which was scored in 29 out of 45 lessons. In contrast, the feature of ‘teacher engages learners in planning investigations’ was only observed in one lesson. Also, the inquiry feature ‘learners evaluate the explanations in light of alternative explanations’ was observed in only three lessons. Figure 7.1 below shows the frequency of each feature presented in the 45 observed lessons (presented from high to low frequency).

Figure 7. 1. The frequency of each feature presented in the 45 observed lessons



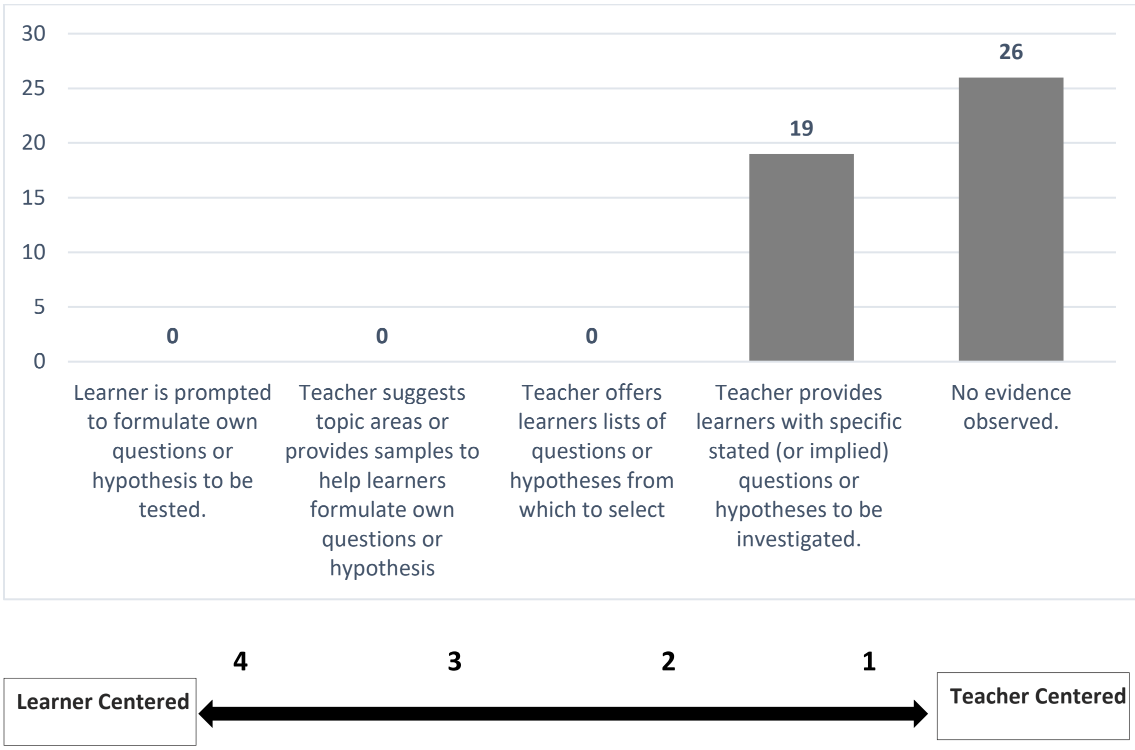
Although some teachers were able to a certain extent to exhibit some of the essential features of classroom inquiry as suggested by NRC (2000) in their teaching practices, the level of student autonomy in the observed lessons was rather limited. To illustrate, students were not given enough opportunity to take an active initiative in any of the 45 observed lessons. For example, none of the observed science teachers promoted students to formulate their own question to be investigated or even to choose a question from a list. Figure 7.2 below shows the direction of the observed inquiry features which was very teacher-centred.

Figure 7. 2. The direction of the observed inquiry features



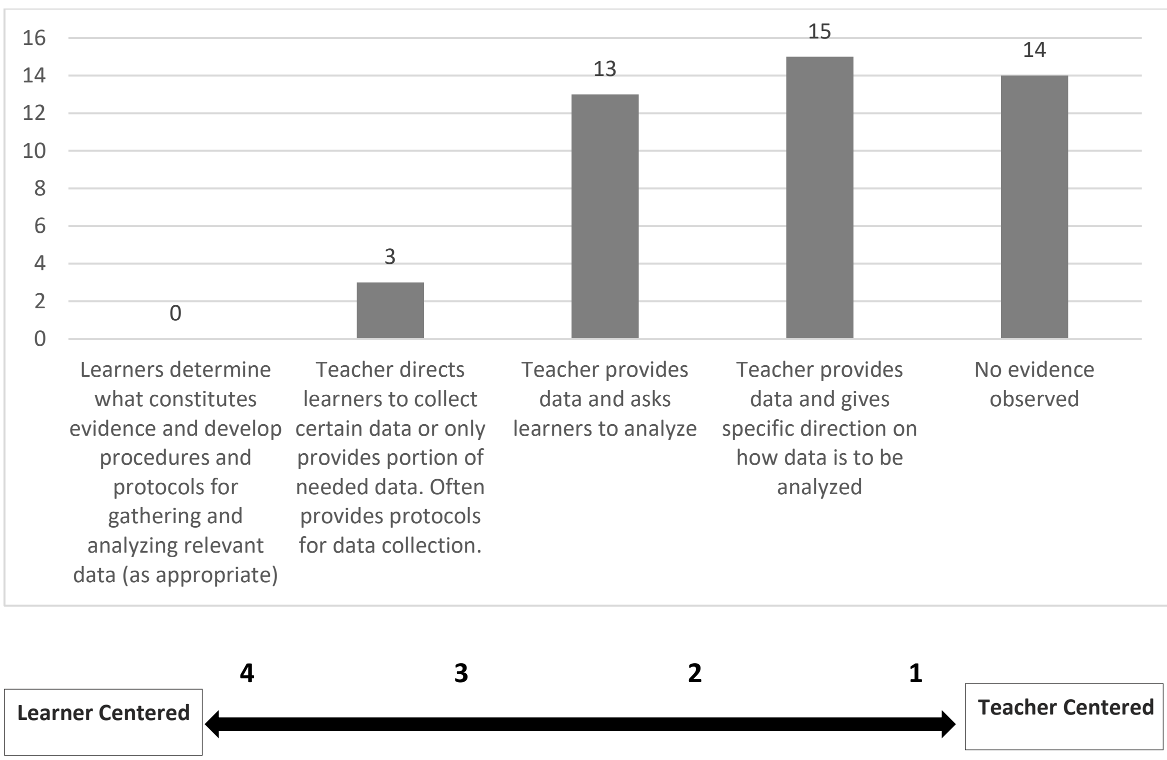
The inquiry feature ‘learners are engaged by scientifically oriented questions’ was observed during 19 out of 45 lessons. However, the direction of the questions in all of these 19 lessons was very teacher-centred. In other words, the questions were directly provided by the observed science teachers and the students had no role in deciding which question they would like to investigate. For example, T1 asked his students in grade 5 to find out how the sun heats the earth. T1 asked his students to work in groups to find an answer to the question from the science textbook. So, in this example, the question and the source of the answer were provided, and the students’ role was to find the answer from the textbook. In addition, the second category of the STIR rubric, teacher engages learners in planning investigation, was only observed during one lesson and even in that lesson the students were provided with the procedures and protocols to conduct the investigation. Therefore, the observational findings suggest that Saudi science teachers rarely engage students in designing and planning investigations. Figure 7.3 below shows the scores of the inquiry feature ‘learners are engaged by scientifically oriented questions’ on the STIR rubric across the 45 observed lessons.

Figure 7. 3. Learners are engaged by scientifically oriented questions



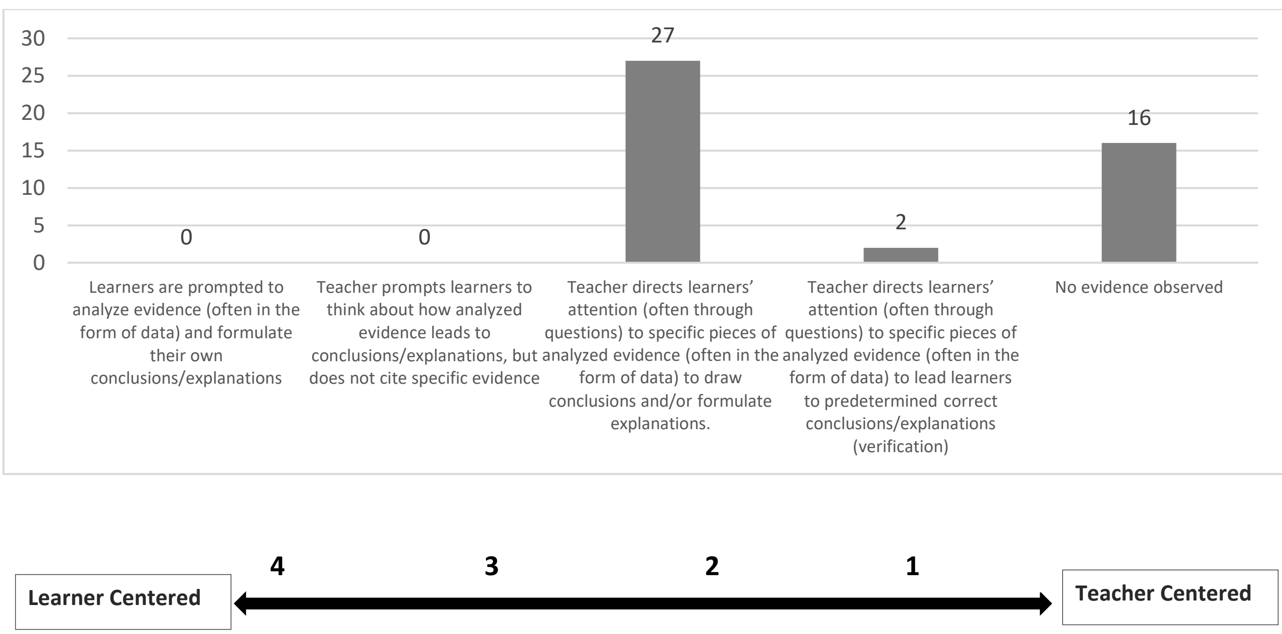
The third category of the STIR rubric, teacher helps learners give priority to evidence, was observed in 31 science lessons which was the most frequently observed category of the STIR rubric. For example, T28 provided her students with a task to find out the differences between metals, non-metals, and metalloids. T28 provided students with materials and asked them to notice and record the heat conduction, appearance, malleability, and ductility of each material. So, in this example, T28 gave her students the opportunity to observe and collect data about three types of materials. However, T28 directed the students to collect certain data. Although teachers gave more autonomy to students than the previous category of the STIR rubric, it is still in the teacher-centred direction. Also, it was noted that students were mostly given the opportunity to collect data or information from the school textbooks while other sources such as books and the internet were not used or encouraged in the observed lessons. This suggests that students were not given the opportunity to have their own initiative to use a variety of sources in their learning process. Figure 7.4 below shows the findings of this category by using the STIR rubric.

Figure 7. 4. Teacher helps learners give priority to evidence



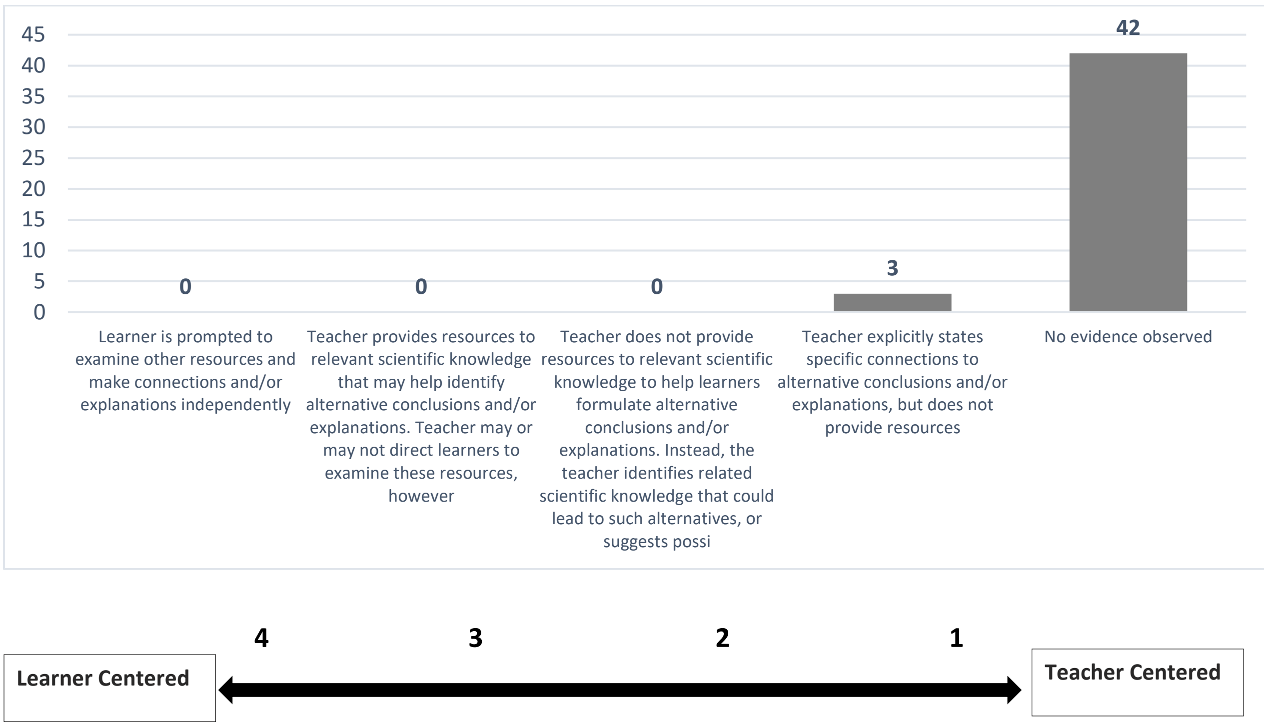
Another feature of inquiry that was observed in many lessons was ‘learners formulate explanations and conclusions’. This feature was observed during 29 lessons. Nevertheless, in all cases, teachers directed students’ attention to specific pieces of analysed evidence. For example, T1 asked students to explain why the temperature varied from city to city or country to country. In order for the students to conclude the answer, the teacher took out three students and distributed them in different locations. He asked the students to imagine that there was a fire in the middle of the three students. Then, he asked the students which one of them felt the most heat. The students then concluded that the differences in the temperature between the three students was due to the different amounts of radiation received from the fire based on their relative locations. In this example, the teacher drew the students' attention to a scenario in front of them in order to deduce how the temperature varies from country to country or from one city to another. Figure 7.5 below illustrates the result on the STIR scale.

Figure 7. 5. Learners formulate explanations and conclusions



The inquiry feature 'learners evaluate the explanations in light of alternative explanations' was only noted three times during the 45 observations (see figure 7.6 below).

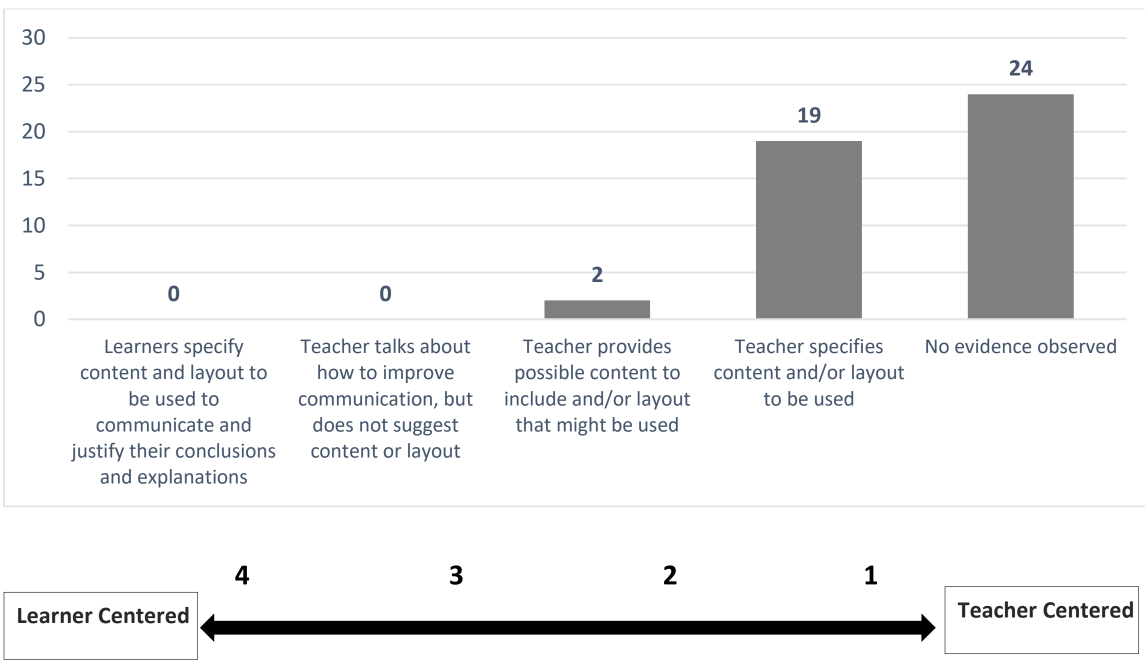
Figure 7. 6. Learners evaluate the explanations in light of alternative explanations



As shown in figure 7.6, in all the three observed cases the teachers explicitly stated specific connections to alternative conclusions and/or explanations. For example, in a high school physics class, T5 made explicit connections to scientists' method of using a galvanometer (an electromechanical instrument used for detecting and indicating an electric current). He explained the parts of this device and where it is used. He then asked students to provide other examples of galvanometer use. Also, T19 in a primary school class made an explicit connection to the stages of the water cycle. T19 drew a picture of a teapot placed on the fire. Then he asked the students what would happen if the water in the teapot was boiling. Then he drew a spoon over the boiling water from the teapot and then he asked his students what happens to the spoon surface when water vapour reached it. Then he linked the teapot example to the water cycle.

The last feature of inquiry in the STIR instrument "learners communicate and justify their proposed explanations" was observed during 21 lessons. However, in all 21 cases, the teachers again managed the discussion, and the way of students' communication was mostly specified and directed by the teachers. So, the students were not given opportunities for their own initiative and the communication was mainly based on teacher-centred direction (see figure 7.7).

Figure 7. 7. Learners communicate and justify their proposed explanations

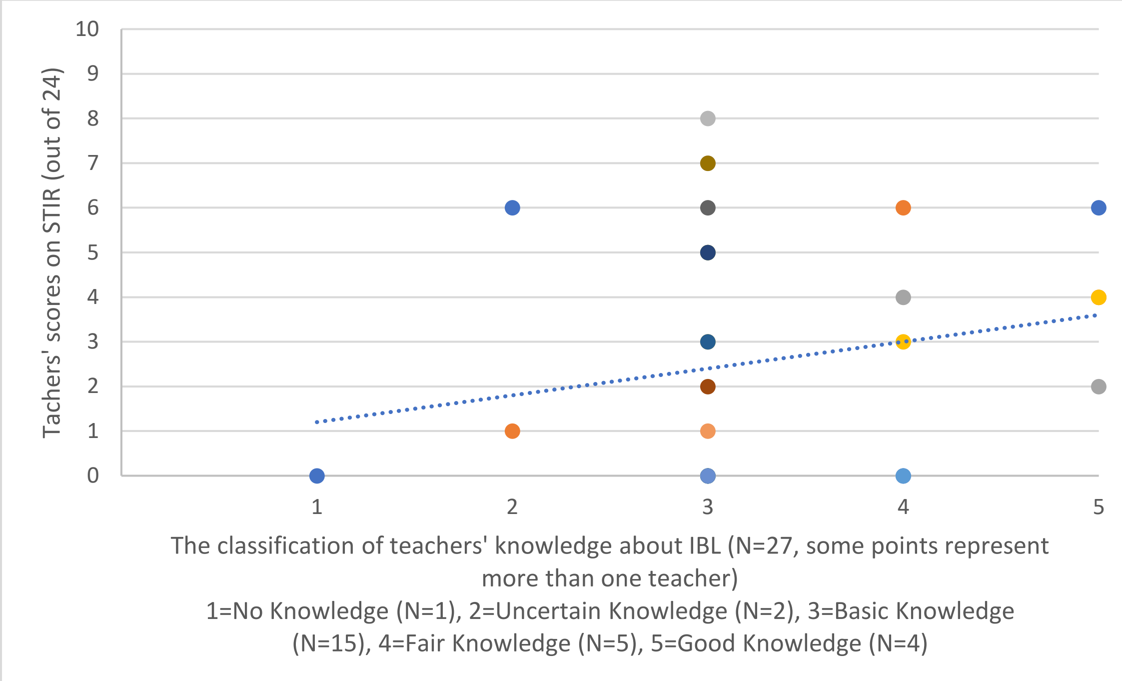


Although some teachers allowed their students to communicate and justify their ideas, the direction of those interactions was mostly teacher-centred. Student-to-student communications were very limited in most cases. On the other hand, teacher-to-student interactions were dominant in most observed lessons. Furthermore, in most cases, students had no role in deciding the content and the format of the communications. In addition, this feature of inquiry was not presented during the other 24 lessons. That could also confirm that Saudi science teachers are still attached to the traditional teaching method.

7.3. The Relationship Between Teachers' Knowledge of IBL and Classroom Practice

The analysis of the interview and observation data indicates that there was no relationship between teachers' knowledge and their practice in the classroom related to IBL. Some teachers who were classified as having basic knowledge about IBL, based on their own definitions in the interviews, demonstrated better IBL practice than those who were classified as having good knowledge about IBL. In general, teachers did not demonstrate strong practice of IBL in the observed lesson: the highest score on the STIR instrument was found to be 8 out of 24. Figure 7.8 below provides a comparison between the scores of the 27 science teachers on the STIR instrument in the observed lessons and their classification of IBL knowledge based on their own definition of IBL in the interviews (the classification of teachers' knowledge about IBL was presented in table 5.3, section 5.2.1).

Figure 7. 8. Relationship between teachers' knowledge classification about IBL in the interviews and their scores on the STIR instrument in the classroom observations

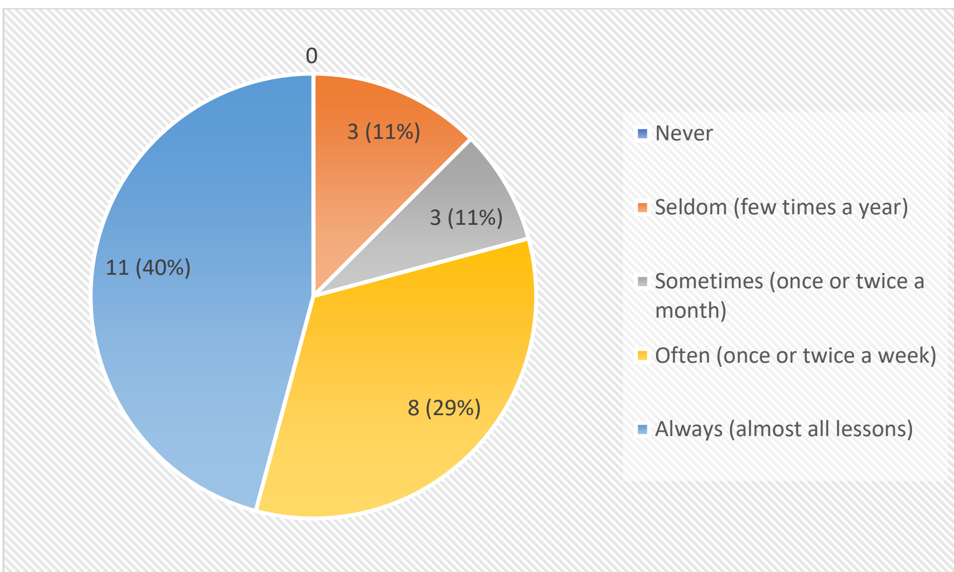


As shown in figure 7.8, the teacher who was classified as having no knowledge about IBL in the interview was also scored zero on the STIR instrument in the observation. This indicates that this teacher had both a lack of knowledge and a lack of practice of IBL. Regarding the two teachers who were classified as having uncertain knowledge about IBL, one of them demonstrated a level of practice of IBL that was as good as, if not better than, that of many of the teachers whose understanding was better. Also, among the 15 teachers who were classified as having basic knowledge about IBL, three teachers were scored zero on the STIR instrument in the observation. Interestingly, the top two scores in the STIR instruments were 7 and 8 which were for three teachers who were classified as having basic knowledge about IBL. Additionally, two teachers among the five teachers who were classified as having fair knowledge about IBL were scored zero across all STIR instrument categories which means that none of the five essential features of IBL was presented in their observed lessons. The limitations of the lesson sampling in this study are discussed in section 10.5. However, taken together, these findings indicate that across the group of teachers, IBL practice is generally at low levels, and there is no clear association between levels of IBL knowledge and levels of IBL practice.

7.4. Interview Findings Related to Teachers' Implementation of IBL

Teachers were asked in the interviews how often they use IBL, as defined by NRC (2000), in their teaching. The finding of this question is summarised in figure 7.9. below.

Figure 7. 9. Teachers' answers to the question 'how often do you use IBL in your teaching' in the interviews



As can be seen from figure 7.9 above, 11 out of 27 teachers indicated that they implement IBL as defined by NRC (2000) in almost all lessons. However, the observational results show that some teachers, who said that they use IBL in every lesson, did not implement a full IBL during the observed lessons as defined by NRC (2000). For example, T7, T14, T21, and T25 implemented only two features of IBL in the observed lessons. In addition, T24 stated that "I use IBL in every lesson". However, none of the five essentials features of IBL as stated by NRC (2000) were observed in T24's class. Only two teachers, among the 11 teachers who said that they implement IBL in every lesson, applied the five features of IBL as defined by NRC (2000) during their observed lessons. For example, all the five essential features of IBL were observed in T5's class. However, when T5 was asked about the way of developing IBL in his class, he did not mention any feature of IBL as defined by NRC (2000). Hence, T5 is an example of a teacher who represented a good practitioner of IBL but who could not necessarily articulate it.

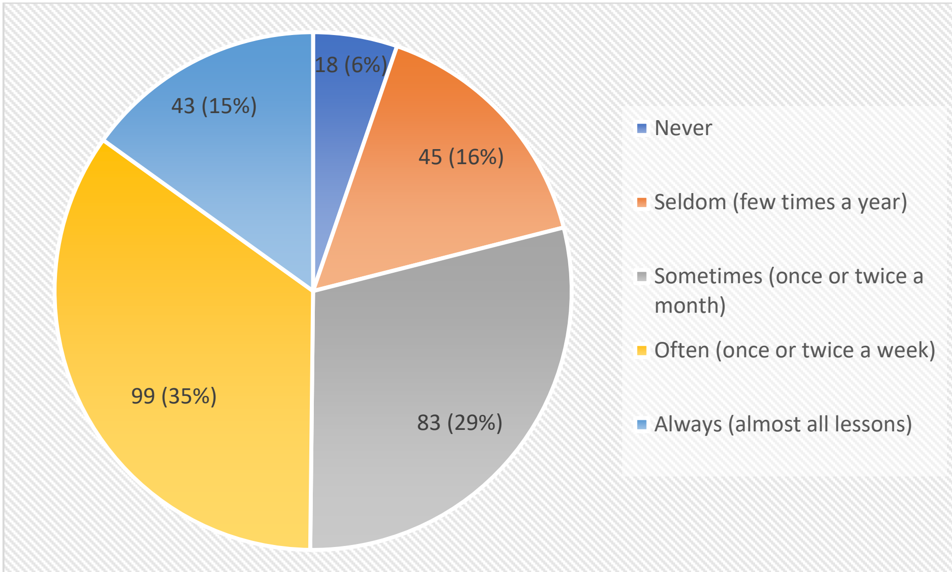
Some teachers reported in the interviews that they implement IBL as defined by NRC (2000). However, from the follow up question about the way of implementing IBL, it appears that their descriptions of IBL implementation were inconsistent with the NRC's definition of IBL. For example, T8 stated that "I often apply IBL in my lessons, I show students a video, experiment or picture and they learn from it". So, T8 thinks that showing students a video, experiment or picture can be a way of introducing IBL into the lesson. However, in the observation, four features of IBL as defined by NRC (2000) were observed in T8's class. Thus, some teachers may implement some aspects of IBL without realising or being able to articulate them clearly. Unlike T8, T11 also reported in the interview that "I use IBL in every lesson", but when he was asked about the way of implementing it, he said "I request students to do research about a topic such as Osteoporosis". So, T11 described IBL as conducting research. Therefore, the findings of this study indicate that even though some teachers claim that they use IBL in their teaching practice, the question remains what version of IBL they implement. It is important to notice that IBL could be understood differently that leads to different ways of implementing it.

In order to compare between teachers' verbal statements and their actual implementation of IBL in the observed lessons, they were asked a follow up question in the interviews if they used IBL during the observed lessons or not. Teachers' answers were classified into three categories. The first category said 'yes' which was 16 out of 27 teachers. The second category said 'no' which was 4 teachers. The last category said 'not sure' which was 6 teachers. It was surprising that 5 teachers said that they used IBL during the observed lessons. However, based on observational data, their score across the six categories of the STIR instrument was zero, meaning they had not used any of the IBL features. In contrast, 2 teachers said that they did not implement IBL in the observed lessons, but some categories of the STIR instrument were observed in their lessons. This is an indication that teachers' lack of a clear understanding of IBL that corresponds to the NRC definition could influence their practices and the consistency between what they are doing and what they think they are doing. Further discussion will be provided in section 9.4.

7.5. Online Questionnaire Findings Related to Teachers' Implementation of IBL

In the online questionnaire, teachers were asked to indicate how often they use IBL as defined by NRC (2000) in their teachings. The result was summarised in figure 7.10 below.

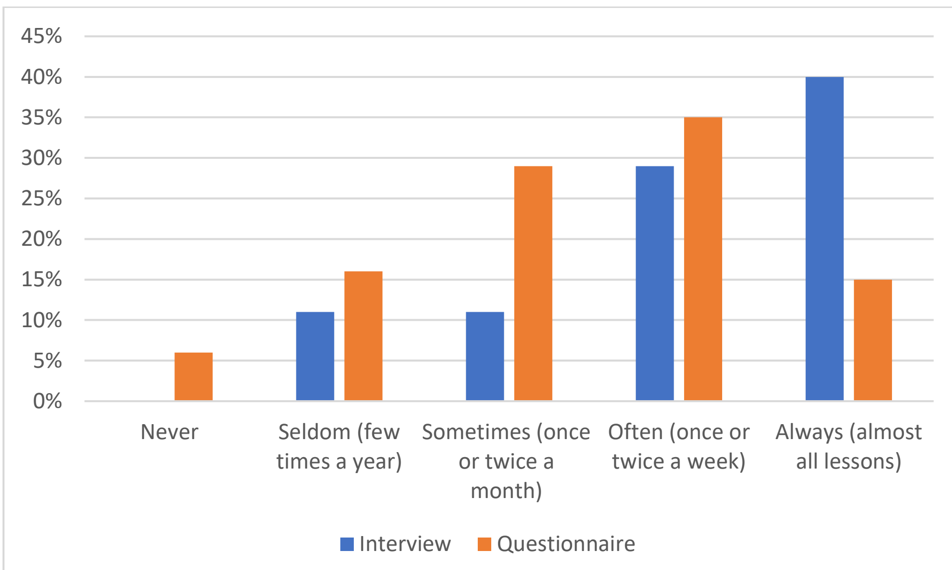
Figure 7. 10. Teachers' answers to the questions 'how often do you use IBL in your teaching?' in the questionnaire



As shown in figure 7.10 above, 35% of the participants indicated that they use IBL as defined by NRC (2000) once or twice a week while 29% of participants reported that they implement IBL sometimes (once or twice a month). In addition, 15% of participants stated that they always apply IBL in their teaching. Figure 8.9 also shows that 6% of the participants reported that they never use IBL in their teaching while 16% of participants rarely apply IBL.

By comparing the interview findings to the questionnaire findings regarding the question 'how often Saudi science teachers use IBL as defined by NRC (2000) in their teachings', some differences can be highlighted. Firstly, none of the participants said in the interviews that "I never use IBL" while 6% of the questionnaire sample indicated that they never use IBL. Secondly, 11% of the interview sample reported that they use IBL sometimes compared to 29% of the questionnaire sample. Thirdly, 41% of the interview sample claimed that they always implement IBL compared to 15% of the questionnaire sample. So, the proportion of participants who reported believing that they always implement IBL in their teachings was higher in the interviews than the questionnaire (figure 7.11 below shows a comparison between interview and questionnaire findings for the question 'how often Saudi science teachers use IBL'). However, the observational data showed that some teachers claimed that they use IBL in almost all lessons, but their actual teachings did not reflect an IBL lesson as suggested by NRC (2000).

Figure 7. 11. A comparison between interview and questionnaire findings for the question 'how often do you use IBL in your teaching'



In order to further investigate the way of implementing IBL in classrooms, teachers were asked in the questionnaire to explain how they implement IBL in their teachings if they do so. A total of 107 out of 288 participants responded to this question. Many activities of implementing IBL came up from the collected data. Some of these activities of IBL partially correspond to the NRC's definition of IBL. For example, a teacher described the way of implementing IBL by stating that:

> According to the science textbooks in Saudi Arabia (McGraw-Hill textbook series), the lesson begins with observing a picture (see and ask) and then followed by an inquiry activity in all science lessons, and after reaching a solution to the problem (the activity) we begin to display and discuss the concepts and then we complete the 5E learning cycle.

So, in this example, the teacher mentioned some IBL activities that are in line with the NRC's definition of IBL such as making observations, proposing answers and explanations. Another teacher stated a different way of implementing IBL when saying "through the participation of students in explaining the lesson and through designing and carrying out experiments". So, in this example, the teacher allows the students to plan and carry out experiments which was rarely mentioned by participants in this study. In another example, a teacher stated that "I develop IBL by presenting a video or something scientific to promote students' thinking, then they analyse and deduce answers for the questions". Although in this statement the teacher did not specify the type of video, the teacher allows students to observe, analyse, and conclude answers.

On the other hand, some teachers indicated activities that are inconsistent with the NRC's definition of IBL. For instance, a teacher said that "I often implement IBL in my teaching". However, when this teacher was asked about the way of implementing IBL described that "I implement IBL by giving the students homework to collect information from the internet about a specific topic". So, this teacher thought that she implements IBL because she gave her students homework to collect information. Likewise, another teacher explained the way of implementing IBL by saying "giving students homework". In the same vein, another teacher indicated in the questionnaire that he often implements IBL in his teaching. However, when he explained the way of implementing IBL, he responded that "I introduce the title of the topic to the students via emails before the day of the lesson, then I start receiving students' questions, ideas and observations about the topic in the next day during the lesson". So, in this example, it appears that the teacher linked students' preparation for a topic to IBL. Thus, the findings of this study suggest that the manner of teachers' implementation of IBL is varied irrespective of their correct understanding of IBL. Table 7.2 below summarises the main recurring themes extracted from participants' answers to the open-ended question 'If you implement IBL in your teaching, can you explain how you do it?'.

Table 7. 2. The main recurring themes extracted from participants' answers to the open question of 'If you implement inquiry-based learning in your teaching, can you explain how you do it?'

Activities of IBL	**Frequency**
Posing questions	41
Researching	32
Carrying out experiments	28
Drawing a conclusion	20
Problem solving	18
Explanation	14
Making observation	14
Analysis	9
Proposing answer	9

Table 7.2 above revealed that posing questions, searching, and carrying out experiments were the most repeated themes throughout the teachers' responses to their way of implementing IBL. On the other hand, there are some aspects of the adopted IBL definition that were hardly ever mentioned by participants, including using tools to

gather, analyse, and interpret data; proposing answers and predictions; communicating the results; and formulating alternative explanations. These findings confirm the interview results about the IBL activities that were mentioned by the participants (table 5.17) which showed that posing questions, carrying out experiments, and researching were frequently reported by the interview participants as IBL activities.

The activity that was mentioned most often by participants when explaining the way of implementing IBL was posing questions. However, the observational data indicated that teachers may pose a question to test students' knowledge, but it is not a scientifically oriented question. In other words, teachers may ask their students a question and hear immediate answers without allowing their students to find out or make an investigation. Some participants indicated in the interviews that they pose a question as a way of implementing IBL. However, based on the observational data, they asked students a general question to examine their knowledge. For example, T3 was asked in the interview about how he implements IBL as defined by NRC (2000), and he commented that "I use IBL in about 85% of my teaching practice, I use questions, for example, in today's lesson I asked my students the following question: do you think there are living creatures that can be seen by a microscope? and I let them think". Although T3 listened to students' answers, he did not provide an opportunity for the students to investigate this question. Therefore, some teachers in this study may think that they implement IBL because they ask their students questions.

7.6. Summary of Teachers' Implementation of IBL

In summary, even though some of the five essential features of IBL as suggested by NRC (2000) were observed in the classrooms, the observed features of IBL were mainly controlled and dominated by teachers. Students had little autonomy in deciding the kind of IBL activity or the process of its implementation. Also, the findings of the present study suggest that there is a conflict between teachers' self-reports and the actual implementation of IBL in the classroom. Some teachers did not practise IBL during the observed lessons, but in the interviews, they stated that they use IBL in all lessons. This inconsistency is mainly because Saudi science teachers understand the notion of IBL differently and they use IBL based on their own understandings. Therefore, it is necessary to know exactly what the teacher intended from the term of IBL. On the contrary, some teachers practised many aspects of IBL in their teaching but in the interviews, they could not express clearly how they conduct IBL in their classroom. Additionally, the results of the present study indicate that some teachers think IBL is any form of active learning, so they consider IBL as any kind of learning that engages students in an active role.

Chapter 8: Analysis and Findings of Teachers' Perceptions About the Obstacles to Using IBL

8.1. Introduction

This chapter presents the findings related to the fourth research question which was 'what are Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?'. In order to answer this question, data were collected from semi-structured interviews and an online questionnaire. This chapter is organised into two major sections: (1) interview findings and (2) online questionnaire findings. The next section presents the interview results related to teachers' perceptions about the obstacles they are facing for using IBL.

8.2. Interview Findings Related to Teachers' Perceptions About the Obstacles to Using IBL

The participants were asked in the interviews about the obstacles they face when implementing IBL as defined by NRC (2000). Thematic analysis of the interviews allowed the researcher to draw out five major challenges that were perceived by the participants as obstacles to implementing IBL. These perceived challenges were: lack of resources, large numbers of students in classes, heavy teaching load, students' lack of ability, and heavy curriculum content. Other perceived challenges that were reported less frequently by the participants included students' lack of motivation, and inadequate time allocated for the class period. Table 8.1 below summarises the identified challenges of IBL implementation based on participants' responses in the interviews.

Table 8. 1**.** Themes extracted from teachers' responses to the interview question 'what are Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?'

Theme	Teachers responding	Total teachers (N=27)
Lack of resources	T1, T2, T3, T5, T7, T8, T13, T17, T18, T19, T21, T25, T26, T27, T28	15
Large numbers of students in classes	T2, T5, T6, T7, T9, T10, T11, T13, T18, T23, T27	11
Heavy teaching load	T2, T4, T7, T9, T11, T13, T22	7
Students' lack of ability	T4, T5, T12, T13, T15, T24	6
Heavy curriculum content	T4, T8, T13, T22, T27, T28	6
Students' lack of motivation	T2, T14, T20, T22	4
Inadequate time for class periods	T18, T22, T27, T28	4
Lesson schedule	T5	1
Lack of teachers' pedagogical knowledge	T14	1

As shown in table 8.1, the participants reported many obstacles that prevent them from implementing IBL. However, there were certain challenges that the participants reported more than others such as lack of resources and large numbers of students in classes. The next sections provide details about the most reported obstacles.

8.2.1. Lack of Resources

As can be seen in table 8.1 above, over half of the participants (55%) highlighted that lack of resources is one of the main challenges of implementing IBL. Those teachers reported that they face difficulties in applying IBL due to lack of resources at their schools including materials, equipment, laboratory facilities, and technology. This can be supported by many statements. For instance, T1 said that “the challenge that I face when trying to use IBL is that there is a lack of resources and some materials and equipment are not available at the school”. Similarly, T3 commented on the obstacles to implementing IBL that “inadequate laboratories at schools hinders us from doing experiments”. T5 also reflected that the lack of resources and poor quality of equipment at school serve as a barrier to using IBL. In response to the question about the barriers to IBL implementation, T5 stated that:

> There is a huge lack of resources in the school’s laboratory, sometimes we try to provide simple materials by ourselves. Also, we are afraid to conduct an experiment because some equipment at schools do not work properly so the students may not trust the teacher if the result was wrong.

So, T5 not only faces an issue with the availability of equipment but also the quality of equipment that is provided. In another example, T17 commented that the school building is not prepared for implementing IBL when he reported that “the school buildings are not equipped for IBL implementation even the curriculum materials are not available, and the practical lesson and its textbook has been cancelled”. A similar issue was reported by T21 who stated that:

> For me personally, the biggest obstacle that I face is the school building, where I work in a small, rented, and old building. There is no laboratory equipped with

adequate equipment. Also, the classrooms are very small and unsuitable for experiments.

T19 commented that “there is a lack of availability of means, laboratories and technology. For example, the internet is not available at school and some students do not have access to the internet at their home”.

From the above examples, it can be noticed that, from the teachers’ point of view, schools’ lack of necessary resources prevents teachers from using IBL. In spite of the fact that the participants were from different school environments and levels, the issue of lack of resources was common among the participants. However, the proportion of primary school teachers who perceive the lack of resources as an obstacle to IBL implementation was almost twice as high as the proportion amongst middle and high school teachers. This could indicate that the issue of lack of resources was more common among primary school teachers. However, the differences in teachers’ perceptions of IBL challenges will be further tested in the survey questionnaire with a larger sample. Table 8.2 below illustrates the classification of the interviewed teachers who perceive the lack of resources as an obstacle to IBL implementation.

Table 8. 2**.** Classification of the interviewed teachers who perceive the lack of resources as an obstacle to IBL implementation

Gender		**Teachers’ school levels**			**Teaching experience**					**Teachers’ specialisations**				
Male N=19	Female N=8	Primary N=9	Middle N=9	High N=9	0-5 years N=2	6-10 years N=8	11-15 years N=4	16-20 years N=5	Over 20 years N=8	Biology N=8	Chemistry N=5	Physics N=6	General science N=6	Other N=1
10 (53%)	5 (62%)	7 (78%)	4 (44%)	4 (44%)	2 (100%)	4 (50%)	3 (75%)	1 (20%)	5 (62%)	4 (50%)	3 (60%)	4 (67%)	4 (67%)	0

8.2.2. Large Numbers of Students in Classes

As can be noted from table 8.1 above, 11 teachers (40%) among the interviewed teachers reported that they face challenges in implementing IBL due to large numbers of students in their classes. Many of the comments made by the interviewed teachers support this view. For example, T6 reflected that:

> The most difficult thing is the large number of students in the class which may become a barrier. For example, I cannot pose a question to every student because it takes time and I have to cover the curriculum.

Similarly, T7 pointed out that:

> The number of students in the class is between 36 and 37 and the space of the classroom is relatively small so if I would like to ask a student to come out and stand in the front of his classmates, it takes five minutes and causes chaos in the classroom.

Likewise, T9 indicated that “IBL is suitable for a small number of students in the class. The number of students in my class is between 35 to 40 students which is a major challenge”. Also, T18 and T23 reported that large numbers of students in classes make it difficult to control them. So, large numbers of students in classes may cause practical management issues in implementing IBL. The issue of large numbers of students in classes was reported by teachers from different genders, school levels, experience, and specialisations. Table 8.3 below illustrates the classification of teachers who perceive large numbers of students in classes as an obstacle to IBL implementation.

Table 8. 3. Classification of the interviewed teachers who perceive large numbers of students in classes as an obstacle to IBL implementation

Gender		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisations**				
Male N=19	Female N=8	Primary N=9	Middle N=9	High N=9	0-5 years N=2	6-10 years N=8	11-15 years N=4	16-20 years N=5	Over 20 years N=8	Biology N=8	Chemistry N=5	Physics N=6	General science N=6	Other N=1
9 (47%)	2 (25%)	3 (33%)	5 (56%)	3 (33%)	2 (100%)	1 (12%)	2 (50%)	2 (40%)	4 (50%)	4 (50%)	1 (20%)	3 (50%)	3 (50%)	0

8.2.3. Heavy Teaching Load

Seven out of 27 teachers mentioned in the interviews that they face difficulty in implementing IBL because of their heavy teaching load. For example, T7 is a biology teacher at high school level; he indicated that he has multiple tasks to do at school when he said:

> Workload burden at school is a challenge because I have 24 lessons per week, and I am a health and student advisor and I have other work to do after the lessons, so when can I prepare for students? I also have supervision duty every day.

In another example, T9 claimed that "the heavy teaching load limits teachers' efforts, especially in the last few lessons". So, T9 argued that heavy teaching load could lead to low performance. Similarly, T13 reported that "heavy teaching load serves as a barrier to implementing IBL because it requires a high mental effort and concentration". So, based on the above-mentioned examples, it is suggested that heavy teaching load may negatively affect teachers' performance and prevent teachers from implementing IBL.

Four teachers, among those seven teachers who reported the issue of heavy teaching load, were from the middle school level while two teachers were from the primary school level. Interestingly, the two primary school teachers who reported this issue were from the same school. So, this issue might be related to a specific school environment. Additionally, only one teacher from the high school level and one female teacher reported the challenge of the heavy teaching load. Table 8.4 below illustrates the classification of teachers who perceive heavy teaching load as an obstacle to IBL implementation.

Table 8. 4 Classification of the interviewed teachers who perceive heavy teaching load as an obstacle to IBL implementation

Gender		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisations**				
Male N=19	Female N=8	Primary N=9	Middle N=9	High N=9	0-5 years N=2	6-10 years N=8	11-15 years N=4	16-20 years N=5	Over 20 years N=8	Biology N=8	Chemistry N=5	Physics N=6	General science N=6	Other N=1
6 (32%)	1 (12%)	2 (22%)	4 (44%)	1 (11%)	1 (50%)	2 (25%)	0	2 (40%)	2 (25%)	3 (37%)	0	2 (33%)	1 (17%)	1 (100%)

8.2.4. Students' Lack of Ability

In the interviews, six teachers reported that students' lack of ability is one of the challenges of IBL implementation. Two teachers indicated that the issue of the lack of students' reading and writing skills is a major obstacle to implementing IBL. For instance, when T4 was asked about the obstacles he faces when using IBL, he commented that "poor reading and writing skills among students are a major obstacle". Likewise, T12 stated that "when I ask students, especially written answer types, they cannot answer it properly because they are not trained to write, and they are unable to understand the question by themselves". T13 also mentioned the issue of the lack of students' critical thinking ability when he stated, “students do not know about critical thinking so they cannot criticise the information”. Likewise, T15 reported that “students are not prepared for IBL”. Additionally, T24 indicated that “the level of students is very weak, they do not want to research or apply”. So, the above-mentioned teachers reported obstacles that are associated with students’ abilities and skills. The obstacle of the lack of students’ abilities was reported in the interviews by three high school teachers and three primary school teachers. The three primary school teachers were from the same school. In addition, none of the middle school teachers who were interviewed reported this issue. Table 8.5 below illustrates the classification of teachers who perceive students’ lack of ability as an obstacle to IBL implementation.

Table 8. 5. Classification of the interviewed teachers who perceive students’ lack of ability as an obstacle to IBL implementation

Gender		**Teachers’ school levels**			**Teaching experience**					**Teachers’ specialisations**				
Male N=19	Female N=8	Primary N=9	Middle N=9	High N=9	0-5 years N=2	6-10 years N=8	11-15 years N=4	16-20 years N=5	Over 20 years N=8	Biology N=8	Chemistry N=5	Physics N=6	General science N=6	Other N=1
5 (26%)	1 (12%)	3 (33%)	0	3 (33%)	0	3 (37%)	1 (25%)	1 (20%)	1 (12%)	2 (25%)	1 (20%)	1 (17%)	1 (17%)	1 (100%)

8.2.5. Heavy Curriculum Content

In the interviews, six out of 27 teachers reported that the curriculum contains a large amount of content that needs to be covered which could serve as a barrier to implementing IBL. Among those six teachers, four teachers were from the primary school level and two teachers were from the middle school level. For example, T28, a primary school teacher, commenting on the obstacles to implementing IBL, noted “the abundance of content in the curriculum and its length". Similarly, T8 mentioned, "the length of the curriculum" as an obstacle to IBL implementation. The challenge of heavy curriculum content was not reported by any of the high school teachers who were interviewed in this study. This result is somewhat counterintuitive because the curriculum content of the high school level might typically be thought of as being heavier than at the middle and primary school levels. Also, teachers' perception of heavy curriculum content as an obstacle to IBL implementation was more common among teachers who had 10 or less years of experience. This is also another indication that the perceived challenges of IBL implementation might be influenced by different variables. However, the differences in teachers' perceptions about IBL challenges between different variables will be further tested in the survey questionnaire with a larger sample. Table 8.6 below illustrates the classification of teachers who perceive heavy curriculum content to be an obstacle to IBL implementation.

Table 8. 6. Classification of the interviewed teachers who perceive heavy curriculum content as an obstacle to IBL implementation

Gender		**Teachers' school levels**			**Teaching experience**					**Teachers' specialisations**				
Male N=19	Female N=8	Primary N=9	Middle N=9	High N=9	0-5 years N=2	6-10 years N=8	11-15 years N=4	16-20 years N=5	Over 20 years N=8	Biology N=8	Chemistry N=5	Physics N=6	General science N=6	Other N=1
3 (16%)	3 (37%)	4 (44%)	2 (22%)	0	1 (50%)	3 (37%)	1 (25%)	1 (20%)	0	2 (25%)	0	1 (17%)	2 (33%)	1 (100%)

8.2.6. Other Reported Obstacles to IBL Implementation

There were few other reported issues of using IBL that were extracted from the interview data. As shown in table 8.1 above, four teachers reported that the lack of students' motivation hinders the implementation of IBL. Furthermore, four teachers indicated that the class period (lesson length) is inadequate for the implementation of IBL. Moreover, T5 reported that the allotted time slot for the science lesson can play a role in implementing IBL because students begin to feel tired at the end of the school day. T5 stated that:

> … the seventh lesson at the end of the day is not the same as … the first and second lessons of the day because students tend to have better attention in the morning than the afternoon time.

Interestingly, only one teacher reported in the interview that the lack of teachers' pedagogical knowledge is an obstacle to implementing IBL. T14 commented on the obstacles to implementing IBL that "teachers' lack of knowledge about some steps to do IBL and lack of attention towards this kind of practice [is an obstacle]". So, in this quote, T14 reported that the lack of teachers' knowledge about IBL can be because of a lack of interest in IBL.

The next section presents details of the online questionnaire findings that are related to teachers' perceptions about the challenges of IBL implementation.

8.3. Online Questionnaire Findings Related to Teachers' Perceptions About the Obstacles to Using IBL

In the online questionnaire, teachers were asked to express their level of agreements to statements about potential challenges of implementing IBL. Table 8.7 below presents the percentage, frequency, and mean of science teacher responses from high to low mean.

Table 8. 7. The percentage, frequency and mean of science teacher responses to the scale of teachers' perceptions about IBL challenges in the questionnaire

To what extent the following challenges prevented you from implementing IBL in teaching science	**Not a Challenge**		**Slight Challenge**		**Moderate Challenge**		**Large Challenge**		**Major Challenge**		**Mean**
	%	N	%	N	%	N	%	N	%	N	
The large number of students in the class	13%	36	10%	29	13%	38	20%	58	44%	127	3.73
The curriculum contains a large amount of content that needs to be covered	15%	45	11%	31	8%	23	23%	66	43%	123	3.66
Lack of resources	13%	38	13%	38	14%	40	16%	45	44%	127	3.64
The class period is insufficient to apply IBL	21%	61	18%	51	20%	58	18%	52	23%	66	3.04
The school system does not encourage changes	25%	71	16%	47	18%	52	16%	46	25%	72	3.00
Lack of students' motivation	16%	45	19%	55	30%	88	20%	58	15%	42	2.99
It requires too much preparation time	21%	60	21%	60	19%	56	18%	53	21%	59	2.97
The assessment of students' learning	21%	62	21%	60	22%	63	15%	42	21%	61	2.93
Lack of students' abilities	12%	35	24%	69	35%	99	21%	61	8%	24	2.90
Lack of teachers' professional development	22%	64	22%	62	24%	68	17%	50	15%	44	2.82
Classroom management issues	52%	151	15%	43	13%	36	12%	35	8%	23	2.08
My insufficient pedagogical knowledge	49%	142	21%	61	11%	32	12%	33	7%	20	2.06
My insufficient content knowledge	53%	154	18%	51	13%	37	8%	23	8%	23	1.99
Average mean											2.90

As shown in table 8.7 above, the level of the challenges of IBL implementation was rated differently. The overall mean was 2.90 which indicates that participants had difficulties in implementing IBL. The highest mean of 3.73 was related to the statement 'the large number of students in the class'. This was followed by the statement 'the curriculum contains a large amount of content that needs to be covered' with a mean of 3.66. Also, the third-highest mean of 3.64 was related to the statement 'lack of resources'. In contrast, the lowest mean of 1.99 was related to the statement 'my insufficient content knowledge'. This result is in support of the interview findings, in which the most reported difficulties were the lack of resources and large numbers of students in classes. Furthermore, teacher-related factors such as lack of teachers' pedagogical and content knowledge were the least reported by participants in questionnaire and the interviews.

8.3.1. Differences in Teachers' Perceptions About IBL Challenges According to Their Gender, Teaching School Level, Teaching Experience, and Specialisation

Gender: In order to compare the reported perceived obstacles to implementing IBL between the genders, a Mann–Whitney U test was used. The comparison was done between teachers' mean scores across the 13 questions in table 8.7 above. The result of the Mann–Whitney U test shows that there was no statistically significant difference between male and female science teachers in their perceptions about IBL challenges - the 2-tailed test had a p value greater than 0.05. Table 8.8. below shows the results of the comparison using the Mann-Whitney U test.

Table 8. 8. Results of the Mann Whitney U test on gender related to the scale of teachers' perceptions about IBL challenges in the questionnaire

Domain	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Asymp. Sig. (2-tailed)
Teachers' perceptions about IBL challenges	Male	139	140.74	19562.50	9832.500	.459
	Female	149	148.01	22053.50		
	Total	288				

Teaching school levels: The Kruskal-Wallis test was conducted to examine the differences in teachers' perceptions about IBL challenges according to the teaching levels (primary, middle, and high). The result of the Kruskal Wallis test showed that there was no statistically significant difference ($p > 0.05$) in teachers' perceptions about IBL challenges based on the teaching school level. Table 8.9 below shows the results of the comparison using the Kruskal-Wallis test.

Table 8. 9. Results of the Kruskal-Wallis test on teaching school level related to the scale of teachers' perceptions about IBL challenges in the questionnaire

Domain	Teaching level	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' perceptions about IBL challenges	Primary	85	145.82	.035	2	.983
	Middle	77	143.43			
	High	126	144.27			
	Total	288				

Teaching experience: The Kruskal Wallis test was also performed to examine the differences in teachers' perceptions about IBL challenges according to teaching experience. The result of the Kruskal Wallis test showed that there was no statistically significant difference ($p > 0.05$) in teachers' perceptions about IBL challenges based on teaching experience. Table 8.10 below shows the results of the comparison using the Kruskal-Wallis test.

Table 8. 10. Results of the Kruskal-Wallis test on teaching experience related to the scale of teachers' perceptions about IBL challenges in the questionnaire

Domain	Experience	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' perceptions about IBL challenges	0-1	12	126.58	7.032	5	.218
	2-5 Years	51	133.77			
	6-10 Years	81	154.91			
	11-15 Years	49	159.54			
	16-20 Years	43	148.29			
	Over 20 years	52	125.63			
	Total	288				

Specialisation: The Kruskal Wallis test was performed to examine the differences in mean scores of teachers' perceptions about IBL challenges between different specialisations. Table 8.11 below shows the results of the comparison using the Kruskal-Wallis test.

Table 8. 11. Results of the Kruskal-Wallis test on specialisation related to the scale of teachers' perceptions about IBL challenges in the questionnaire

Domain	Specialisation	N	Mean Rank	Kruskal-Wallis H	Degrees of Freedom	Asymp. Sig.
Teachers' perceptions about IBL challenges	Physics	60	168.55	14.155	4	.007
	Chemistry	67	129.12			
	Biology	91	138.16			
	General science	29	176.48			
	Other	41	125.88			
	Total	288				

The result of the Kruskal Wallis test showed that there was a very strong significant difference (p=0.007) between the mean ranks of at least one pair of groups. This finding indicates that teachers' specialisations have an influence on their perceptions of IBL challenges. As shown in table 8.11, the highest mean rank was 176.48 for teachers who were specialists in general science while the lowest mean rank was 125.88 for teachers who were non-science specialists (the "other" group). This finding indicates that teachers who were specialists in general science were more likely to face challenges in IBL implementation than the teachers who were specialists in physics, chemistry, biology, and non-science specialisations. In contrast, teachers who were non-science specialists (the "other" group) were less likely to face challenges in IBL implementation than the teachers who were specialists in physics, chemistry, biology, and general science. This finding was unexpected because one would expect the opposite. A science specialist teacher would have the advantage of being able to deliver the specific science subject more efficiently compared to non-science specialists that might naturally face challenges in delivering science lessons. A possible explanation for this result could be that non-science specialist teachers may not be fully aware of IBL implementation and the challenges associated with its practice.

To specify where the differences between the groups lie, Dunn's pairwise tests were carried out on each pair of groups. There was evidence (p=0.011) of a significant difference between the group of the teachers who were specialists in physics and those who were non-science specialists. The mean rank of teachers' perceptions about IBL challenges for the physics group was 168.55 compared to 125.88 for the "other" group (non-science specialists). Furthermore, there was evidence (p=0.012) of a significant difference between the group of the teachers who were specialists in general science and those who were non-science specialists (the “other” group). The mean rank of teachers’ perceptions about IBL challenges for the general science group was 176.48 compared to 125.88 for the “other” group. Additionally, there was strong evidence (p=0.008) of a difference between teachers who were specialists in physics and those who were specialists in chemistry. The mean rank of teachers’ perceptions about IBL challenges for the physics group was 168.55 compared to 129.12 for the chemistry group.

There was also evidence (p=0.010) of a significant difference between teachers who were specialists in chemistry and those who were specialists in general science. The mean rank of teachers’ perceptions about IBL challenges for the chemistry group was 129.12 compared to 176.48 for the general science group. Moreover, there was also evidence (p=0.028) of a significant difference between teachers who were specialists in biology and those who were specialists in physics. The mean rank of teachers’ perceptions about IBL challenges for the biology group was 138.16 compared to 168.55 for the physics group. Finally, there was also evidence (p=0.031) of a significant difference between teachers who were specialists in biology and those who were specialists in general science. The mean rank of teachers’ perceptions about IBL challenges for the biology group was 138.16 compared to 176.48 for the general science group. There was no evidence of a difference between the other pairs (other – chemistry, other – biology, chemistry – biology, physics – general science).

8.4. Summary of the Chapter

This chapter addressed teachers' perceptions about the challenges they face when trying to implement IBL. The interview findings revealed that lack of resources, large numbers of students in classes, heavy teaching loads, lack of students' abilities, and heavy curriculum content were the major reported obstacles to using IBL. This finding was also confirmed by the online questionnaires which showed that most of the participants perceived that large numbers of students in classes, lack of resources, and heavy curriculum content are the main challenges for IBL implementation in Saudi Arabian science education. Furthermore, the online questionnaire findings showed that there was a significant difference in teachers' perceptions of IBL challenges according to their specialisations.

The next chapter discusses the study findings.

Chapter 9: Discussion of the Research Findings

9.1. Introduction

The purpose of this chapter is to interpret and discuss the study findings in the light of the research questions and related literature. This study has focused on Saudi science teachers' understandings and beliefs about IBL. It has also aimed to examine the implementation of IBL in Saudi schools and the challenges associated with its practice. A mixed methods approach has been employed to collect qualitative and quantitative data by using classroom observations, semi-structured interviews, and an online questionnaire. Discussion of the research findings is guided by the following research questions:

1. How do Saudi science teachers understand inquiry-based learning?
2. What are Saudi science teachers' beliefs about inquiry-based learning?
3. What are Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?
4. How do Saudi science teachers implement inquiry-based learning in the classroom?

9.2. Discussion of Research Question 1: How Do Saudi science teachers Understand IBL?

This section aims to discuss the findings related to teachers' understandings about IBL. It begins by discussing teachers' different interpretations of IBL. This is followed by a discussion of the levels of teachers' knowledge about IBL. Also, the most frequent themes which were extracted from teachers' responses to the definition of IBL will be discussed. Finally, this section discusses the differences and similarities in teachers' understandings of IBL between sub-groups (gender, teaching school level, teaching experience, and specialisation).

9.2.1. Different Understandings About IBL

The qualitative findings about teachers' understandings of IBL show that Saudi science teachers associate IBL with a number of characteristics, such as researching, deducing, discovering, posing questions and problems, carrying out experiments, making observations, and extracting students' prior knowledge. However, the participants held different understandings about IBL and some of these understandings were inconsistent with the adopted definition of IBL in this study that was based on NRC's (2000) definition. As indicated in Chapter 2, the science textbooks in Saudi Arabia are based on a translation of an American series of science textbooks that were developed according to the NRC (2000) document; therefore, the adopted definition of IBL was suitable for the purpose of this study. The results of this study are in accordance with previous studies, which show that teachers have different interpretations of IBL (e.g., Anderson, 2002; Blanchard et al., 2010; Capps & Crawford, 2013; Capps et al., 2016; Morrison, 2013; Spronken-Smith & Walker, 2010). In that respect, Abd-El-Khalick et al. (2004) recognised that despite the significant amount of research that was aimed at providing an answer to what IBL is or how it should be implemented in practice, there is no single agreed definition of IBL. The teachers in this study may be influenced directly by the variety of descriptions about IBL (i.e., they are aware that there are lots of definitions of IBL, and they adopt some sort of hybrid) – or indirectly (i.e., they have no idea about the range of definitions, but the impact of those definitions on their beliefs and practices is nevertheless evident). It is more likely that teachers in this study were indirectly influenced by the variety of descriptions about IBL because most of them had only a basic knowledge of IBL.

There are several possible explanations for different understandings of IBL. Firstly, IBL could be described in several ways in educational reform efforts and these efforts may reach teachers in a variety of ways. As Gyllenpalm et al. (2010) claim, in the curriculum reform discourse, IBL is defined in various ways, and this causes more confusion about its meaning. An educational reform based upon IBL may be restricted by the fact that several interpretations are assigned to the notion of IBL by policy makers as well as researchers, which would lead to an absence of clarity in teachers' understandings of the reform (Wallace & Kang, 2004). In the Saudi context, IBL has been described in the MOE's guidance by using different interpretations such as a problem-solving model and cooperative learning strategies (refer to Chapter 2 for details). Therefore, these different descriptions of IBL in the MOE's guidance may result in inconsistencies in teachers' understandings of IBL.

Another possible explanation for different understandings about IBL is that teachers may develop their understandings of IBL from various sources, which employ or imply a range of different definitions. As indicated by Eick and Reed (2002), previous experience could have an impact on teachers' understanding of IBL. The interview findings of the current study show that teachers developed their understandings of IBL from different sources such as self-reading, a course at university, official school science textbooks, professional development training, and discussion with colleagues. Although the policy makers in Saudi Arabia have emphasised IBL and have adopted science textbooks that are based on it (refer to Chapter 2 for details), only six out of 27 (22%) teachers indicated in the interviews that they developed their understandings of IBL through the official science textbooks. In addition, almost half of the teachers who were interviewed stated that they developed their understanding of IBL from sources other than the MOE's guidance. This finding is concerning because it might lead to misconceptions or alternative conceptions about the meaning of IBL amongst teachers depending on the quality of the source. Therefore, the implementation of IBL might not occur as intended by policy makers in Saudi Arabia as the policy is diluted and re-interpreted by the other sources or indeed the other sources may be completely independent of the MOE's guidance.

However, the interview findings revealed not only that most teachers who developed their understandings of IBL from unofficial sources appeared to have uncertain or basic knowledge about IBL, but also that most teachers who stated that they had developed their understandings of IBL through official sources seemed to have uncertain or basic knowledge about IBL as defined by NRC (2000). This finding may indicate a lack of clarity in the MOE's guidance, or that teachers may not have a complete commitment in implementing this method. For example, teachers might not have read the guidance thoroughly. Al-Saeed and Almadi (2013) found that Saudi science teachers felt that there are ambiguities in some aspects of the official teacher's guide and there is no clear instruction on how to use the teacher's guide and student textbooks.

Fullan (2007) reported that clarity about the means and goals of the change is a significant factor in the change process. So, lack of clarity is problematic in the implementation stage (Fullan, 2007). If the teachers do not understand the objectives of the change and what to do in practice, therefore, the change is likely to fail in achieving its complete objectives.

9.2.2. Levels of Teachers’ Knowledge About IBL

The qualitative findings reveal that the participants who provided their own definition of IBL appeared to have different levels of understanding and knowledge about IBL. The participants varied from having basic knowledge (defined as those who only mentioned one aspect of the adopted IBL definition), fair knowledge (those who mentioned two aspects of the adopted IBL definition), and good knowledge (those who mentioned three aspects of the adopted IBL definition). It was found that approximately half of the participants appeared to be limited to basic knowledge of IBL. It was also found that fewer than 20% of the participants seemed to have fair knowledge of the IBL. Moreover, it was found that only approximately 10-15% of the participants appeared to have good knowledge of the IBL. In contrast, approximately 4-7% of the participants seemed to have no knowledge of the IBL based on their explicit answers to the question “how do you define IBL?”. This study further found that 17% of the surveyed participants and 7% of the interviewees appeared to have uncertain knowledge of IBL because the answers that they provided that did not conform to the adopted definition of IBL. The following paragraph discusses these findings.

Although the adopted science textbooks in Saudi Arabia were developed in the light of NRC (2000), these findings revealed that most of the participants who provided their own definition of IBL appeared to have partial and incomplete knowledge about IBL as defined in NRC (2000). Other research also found lack of compatibility between teachers' expressed knowledge of IBL and the notion of IBL set forth in reform agendas (Brown, Abell, Demir, & Schmidt, 2006; Capps et al., 2016; Demir & Abell, 2010; Hong & Vargas, 2016; Lotter, Harwood, & Bonner, 2006). The mismatch between the reform initiative demand and teachers' understandings can negatively affect the success of an educational change (Fullan, 2007). So, this finding could help explain the limited implementation of the reform initiative in the Saudi schools.

The qualtitive findings also show that certain aspects of NRC's definition of IBL were not mentioned by all participants, such as planning investigations and communicating the results. This finding is in agreement with other research which found that some IBL characteristics were absent from teachers' understandings such as evidence, explanation, communication, justification (Demir & Abell, 2010), designing investigations (Jiang & McComas, 2015), and evaluation (Chabalengula & Mumba, 2012; Kang et al., 2008). Inadequate and inconsistent knowledge about IBL amongst Saudi science teachers may be explained by the fact that IBL is relatively new in the Saudi context. This explanation is supported by the study reported by Wang and Zhao (2016), who found that American teachers have a better understanding of IBL than Chinese teachers. Wang and Zhao (2016) suggested that this result may be because Chinese teachers have little experience in doing IBL.

Capps et al. (2016) found out that a well-structured definition of IBL was the basis of a sound knowledge of the concept of IBL; two-thirds of their participant teachers had vague knowledge about IB, based on having non-normative IBL definitions. While the current study agrees with the finding of Capps et al. (2016) that the teachers with vague IBL knowledge will tend to describe IBL using alternative activities such as hands-on learning, the present study attempted to quantify the degree of vagueness in their definition by using the number of terms that conform to the adopted IBL definition in their answers.

The proportion of the teachers who were classified as having no knowledge or uncertain knowledge about IBL in the survey questionnaire responses was slightly higher than in the interview responses. The present study found that 17% of the surveyed participants and 7% of interviewees provided inconsistent definitions of IBL. Also, this study found out that 7% of the survey participants mentioned that they had no knowledge of the IBL definition instead of guessing it, compared to 4% of the interviewed participants. This is an anticipated outcome because the interview would typically exert a certain level of pressure for the participant to attempt to provide an answer regardless of whether it is based on prior knowledge or lack of it while the surveyed participants have less pressure on the need to commit to an answer.

It is possible that teachers' own classroom experiences have affected the perceptions of the participants in this research. For instance, teachers' own experience of using classroom activities could influence their interpretation of IBL. In other words, teachers may recall the activities they normally do with students to describe IBL. As a result of the different activities that teachers engage in with students, their interpretation of IBL might vary accordingly. The difference may be more pronounced if teachers with different backgrounds are included in the research as is the case in this study. Furthermore, the most common activites that teachers used to describe IBL are likely to indicate that teachers would potentially use these activites as IBL in their actual practice. Other literature has also shown that teachers describe IBL by using their personal experiences instead of how IBL is described in the reform documents and science education literature (Blanchard & Sampson, 2017; Capps et al., 2016).

Another indication that the participants are confused about the meaning of IBL is that only 11% of the survey questionnaire sample were able to correctly recognise all inquiry and non-inquiry activities and to distinguish between them. This result indicates potential ambiguity in the understanding of IBL among the participants because they had overwhelmingly agreed that both the related and the unrelated statements were in fact aspects of IBL. A few studies have reported similar findings that teachers would attribute both related and unrelated statements to IBL and that they were occasionally confused about distinguishing them. For example, Herrington et al. (2011) found out that some teachers were unable to distinguish between inquiry and non-inquiry activities.

When comparing participants' agreeing/disagreeing to class activities listed in the survey questionnaire versus participants listing the activities in the interview, the interview revealed deeper information about the teachers' understandings. It was possible to guess or simply agree to the statements listed in the survey questionnaire, whereas the interview asked participants to provide the activities that were related to IBL and the teachers were not influenced by any provided information during the interviews. Even with this bias in the survey, only 32% of the respondents had listed only related activities while 68% had mixed activities that suggest a lack of precise understanding of IBL activities. Also, a key difference between the interviews and the survey questionnaire is that in the survey questionnaire the participants were asked to recognise IBL activites while in the interviews teachers were asked to recall IBL activites. So, the data of the present study suggest that teachers were better able to recognise IBL activites than to recall them. As noted by Neisser (2014), people are often better able to recognise things than to recall them.

9.2.3. IBL as Finding Things Out

The most recurrent theme in the qualitative data is that IBL is about finding things out. For, example, 26% of the participants reported that IBL is about researching for information. 'Searching for information, topics or concepts' was recorded by the respondents as part of their definition of IBL. Similarly, 13% of the participants indicated that IBL is about discovering. So, the key idea here is that students find things out for themselves rather than passively receiving information from the teacher. This understanding is in alignment with the theory of constructivism which suggests that students do build their own knowledge (Section 3.1.1). However, most participants did not provide details about the process of researching or discovering information. This indicates that the participants did not have well-structured knowledge; rather they used a very broad interpretation such as researching. This finding is consistent with Morrison (2013) who found that teachers tend to describe IBL by using very broad definition such as "finding things out". Also, the findings of Capps et al. (2016) appear to agree with the finding in the present study that teachers who seemed to have a vague knowledge of IBL were more likely to define IBL by using broad descriptions such as exploring and discovering. It is likely that teachers use a broad definition of IBL because they are unaware of the various components of IBL as the present study found that most teachers appeared to have inadequate knowledge about IBL. Another possible explanation is that teachers might not have a clear distinction between IBL and discovery learning. Swan et al. (2013) found that one of the most significant issues for teachers is the confusion between IBL and discovery learning.

9.2.4. IBL as Deducing or Making Conclusions

The qualitative findings show that 20% of the participants indicated ‘deducing or making conclusions’ when defining IBL. Deducing and inferring go beyond researching and collecting data or information as they require using specific cognitive skills to arrive at a conclusion. This conception is consistent with the idea of NRC (2000), that suggested “cognitive abilities” such as inference, analysis, and classification are necessary aspect of IBL and students need to use them. However, teachers in the present study generally tend to focus on process skills such as researching and experimentation more than cognitive skills when defining IBL. This finding is consistent with data obtained in Kang et al. (2008) and Romero-Ariza et al. (2020). For instance, Kang et al. (2008) found out that the IBL feature of ‘formulating explanations and conclusions’ was reported by teachers to characterise IBL which was found at a low frequency, in 29% of teachers written responses. Likewise, Ozel and Luft (2013) found that teachers rarely used the feature of ‘formulating explanations and conclusions with evidence’ in their descriptions of IBL. Although the participants in the present study did not provide a clear logical account of the steps of deduction, it seems that the term ‘deducing or making conclusions’ was used by them to refer to students' engagement in empirical or non-empirical investigation to find out knowledge or answers to questions by themselves.

9.2.5. IBL as Questioning

Another recurrent theme in the qualitative data that is among the most reported activities used by the teachers in the interviews and survey questionnaires is that IBL is about questioning. In addition, almost all teachers (90%) either strongly agreed or agreed to the statement 'Students ask questions' as an IBL activity in the closed-ended question in the questionnaire. Teachers' understandings of questioning as an element of IBL are in agreement with NRC (2000). In Saudi science classrooms, teachers are encouraged to engage students with scientific questions to be investigated in order to secure their interest. However, the interview and observation data revealed that most participants use questions for two different reasons. Firstly, they ask questions about students' prior knowledge. Secondly, some teachers mainly use a lecture method and pose questions during the lessons for formative assessment purposes. The observation data showed that the teachers asked students questions as a tool to actively engage students in the lesson, but they rarely asked students questions to be investigated. This result suggests that there were misunderstandings about the purpose of questions in IBL lessons among participants. Llewellyn (2013) articulates that a common misunderstanding among science teachers is that IBL requires asking a lot of questions. This finding is consistent with Capps and Crawford (2013) who found that teachers thought they do IBL because they ask questions, without mentioning a scientifically oriented question. In contrast, the finding of the present study is inconsistent with Lotter et al. (2006) in which teachers often describe IBL as providing students with a question or problem to be solved. Furthermore, the finding of the present study is also inconsistent with Ireland et al. (2012) who found that 'students formulate and answer their own questions' was one category of teachers' understandings of IBL. However, the studies of Ireland et al. (2012) and Lotter et al. (2006) did not conduct classroom observations while the present study offers a comparison between teachers' reported conceptions and their actual practices in the classrooms and it was found that most teachers use questions for formative assessment purposes.

9.2.6. IBL as Carrying Out Experiments

The qualitative findings showed that 17% of participants indicated 'carrying out experiments' when defining IBL. Other researchers (e.g., Capps & Crawford, 2013; Hong & Vargas, 2016; Romero-Ariza et al., 2020) also found that teachers often described IBL by using terms such as hands-on activities or experiments. NRC (2000) notes that one of the common myths about IBL is that engaging students in hands-on activities guarantees that IBL is being implemented. Wilcos, Kruse, and Clough (2015) argue that the difference between IBL and teaching science through hands-on activities is the degree to which students are mentally involved. However, it is worth noting that not every mentally-involving activity would count as IBL such as problem-based learning. The observational data showed that the participants in the present study used very structured science activities. In other words, students were taught step by step procedures. So, engaging students in doing experiments and practical work does not always mean that IBL is taking place. In other words, teaching science by IBL is not just about using hands-on activities but minds-on is equally relevant and important component of IBL (Wilcos et al., 2015).

There were some teachers in the present study who only described IBL as 'carrying out experiments' and as a result of this restricted sense, the reform initiative in Saudi Arabia may not be successfully implemented since the idea of doing experiments is not practicable for use in every lesson. This finding confirms that teachers' understanding of the reform play a pivotal role in determining the success of the change (as predicted by Fullan, 2007). Additionally, this finding could help to explain the limited use of IBL in science lessons in Saudi Arabia. Therefore, teachers may need support to differentiate between IBL and simply 'carrying out experiments'. It is also important for teachers to know that IBL does not necessarily involve doing experiments. This finding is consistent with Hong and Vargas (2016) who found that teachers often hold a restricted understanding of IBL that is limited to hands-on activities or 'labs'.

9.2.7. Differences and Similarities in Teachers' Understandings of IBL According to Their Gender, Teaching School Level, Teaching Experience, and Specialisation

One of the novel findings of the present study was that science teachers' understandings of IBL varied according to their genders and teaching school levels. For example, the findings of the present study showed that there was a statistically significant association with gender in the likelihood of regarding IBL as carrying out experiments. The female teachers were more likely than male teachers to describe IBL as carrying out experiments. Furthermore, it was also found that there was a statistically significant association with gender in the likelihood of regarding IBL as posing questions, in their own definitions of

IBL. The male teachers were more likely than female teachers to describe IBL as posing questions. These gender-related differences in teachers' understandings of IBL might be because the education system in Saudi Arabia is gender-segregated, where female and male teachers do not attend the same schools or training programs. As a result of different teaching and learning environments, teachers may have varied views about IBL.

With regard to teaching school levels, the findings of the open-ended question about teachers' definitions of IBL showed that there was a statistically significant association with teachers' school levels in the likelihood of regarding IBL as making observations. Furthermore, the analysis of the survey questionnaire data showed that there was a statistically significant difference in teachers' understandings of IBL according to their teaching school levels. This was an expected finding since the school curriculum is different from one stage to another. So, teachers' practices could differ based on school level. This finding implies that teachers' knowledge of IBL cannot be generalised from one school level to another. Contrary to expectations, the current study found that there was no statistically significant difference in teachers' understandings of IBL based on teachers' experience and specialisations. This outcome was unexpected because those teachers had different educational backgrounds. However, this result could be attributed to the nature of teaching preparation programs in Saudi Arabia. To illustrate, teaching preparation programs for the science subjects (e.g., biology, chemistry, and physics) are similar in Saudi Arabia apart from subject-specific matters.

9.3. Discussion of Research Question 2: What Are Saudi Science Teachers' Beliefs About IBL?

The findings of the interviews and survey questionnaire revealed that most teachers held a strong positive attitude towards IBL. For example, all participants in the interviews agreed that IBL, as defined by NRC (2000), is important and effective in teaching science. Those participants mentioned several reasons justifying their positive attitude towards IBL which are that IBL enhances students' understanding, that IBL promotes self-directed learning, that IBL develops students' abilities and skills, and that IBL enhances psychological factors related to learning such as interest and motivation. Furthermore, the survey questionnaire findings confirm the interview results which showed that the majority of participants either strongly agreed or agreed with all statements about the supposed importance and benefits of IBL as stated in NRC (2000) and the Saudi official documents. So, it is apparent that the participants perceived both a need for the reform and a potential for it to bring benefits (Fullan, 2007). These results are in keeping with previous studies, which showed that teachers tend to hold a positive attitude towards IBL (e.g., Alhendal et al., 2016; DiBiase & McDonald, 2015; Engeln, Euler, & Maass, 2013; MASCIL, 2014; Romero-Ariza et al., 2020).

Although teachers shared limited views and practice of IBL, they apparently held a positive attitude towards IBL. This suggests that teachers seem to understand theoretically the importance of IBL according to the intentions of the reform despite many of them lacking practical knowledge and implementation of IBL. A possible explanation for this finding is that teachers seemed to understand and implement IBL differently from what is assumed in the policy documents. Apparently, the participant teachers were not practically trained to use IBL. This can be supported by the interview findings which showed that more than half of the participants did not engage in professional development programs related to IBL. Furthermore, those teachers who participated in some professional development programs indicated that these programs concentrated on the theoretical side of IBL while less attention was given to practical matters. Also, all teachers agreed in the interviews that they need training and professional development programs. So, the positive attitude towards the reform alone does not guarantee a successful implementation of it. These results reflect those of Kennedy and Kennedy (1996) who also found that even though teachers have positive attitudes towards a reform initiative, they are unlikely to implement it if they do not have a sense of control over the actions needed to implement a desired change. Teachers need to be engaged in professional development programs and require continuing opportunities to learn the new instructional approaches in order to be expected to use them (Loucks-Horsley et al., 2009).

Another possible alternative explanation for the reason of the teachers in the present study expressed a strong positive attitude about IBL is that participants may have a tendency toward socially desirable responses. In other words, teachers may not truly feel so positively about IBL, but rather they provided a socially desirable response. Socially desirability bias occurs when the participants tend to answer questions in a way that will be viewed favourably by others (Krumpal, 2013). Since the Saudi reform is directed by the

MOE, the participants might be keeping in mind that their responses should be favourable to the perspectives of the national reform of the science education.

9.3.1. Differences and Similarities in Teachers' Beliefs About IBL According to Their Gender, Teaching School Level, Teaching Experience, and Specialisation

Another novel finding in this research is that there were statistically significant differences between teachers' beliefs about IBL according to their teaching school levels and specialisations. Three potential explanations are conceivable for these differences. Firstly, it is possible that teachers at different levels or in different specialisms perceive the nature of science differently, particularly in relation to what their students need to learn, and therefore they may value IBL differently. The second possible explanation is that teachers' understandings of IBL might influence their attitude towards IBL. To illustrate, the present study found significant differences between teachers' understandings and beliefs about IBL based on teaching school level. So, the variable of teaching school level was associated with significant differences in two factors: teachers' understandings about IBL and their beliefs about IBL. Also, the survey questionnaire findings indicated that there was a significant positive association between teachers' understandings and beliefs about IBL. The third possible explanation is that teachers' perceptions of IBL challenges might affect their attitude toward IBL. For example, the present study found both teachers' beliefs about IBL and their perceptions of IBL challenges varied significantly according to their specialisations. These findings indicate that the context of classroom teaching (e.g., school level and teaching subject) can influence teachers' attitudes towards IBL. For instance, the survey questionnaire findings revealed that teachers who are specialists in general science were least positive about IBL while their perceptions about the challenges of using IBL were the highest. So, teachers' perceptions of IBL challenges can negatively affect their attitudes towards it.

9.4. Discussion of Research Question 3: How Do Saudi Science Teachers Implement IBL in the Classroom?

NRC (2000) notes that there are full and partial IBL practices. In a full IBL practice, all the five essential features of IBL (learner engages in scientifically oriented questions; learner gives priority to evidence; learner formulates explanations; learner connects explanations to scientific knowledge; and learner communicates and justifies explanations) are expected to be present while only some features are expected to be present in a partial IBL practice (NRC, 2000). As reported by NRC (2000), each feature of IBL could vary from teacher-centred to student-centred. In the 45 science lessons that were observed in this study, there were many examples of partial inquiry. The presence of all five essential features as suggested by NRC (2000) was only observed in the classes of two teachers. The observation data showed that features of 'teacher helps learners give priority to evidence' and 'learners formulate conclusions and/or explanations from evidence' were more prominent in the observed lessons than the other three features of IBL. These two features were found in approximately two-thirds of the observed lessons. On the other hand, the features of 'learners evaluate the explanations in light of alternative explanations' and 'teacher engages learners in planning investigations' were rarely observed in the classrooms. Furthermore, the feature of 'learners are engaged by scientifically oriented questions' was noted in fewer than half of the observed lessons

(42%). This finding suggests that most teachers did not implement all the features of IBL. It also suggests that some teachers did not implement any of the features of IBL. Furthermore, it is notable that when a feature of IBL was presented in a classroom, it tended to be in a teacher-centred direction. The following paragraphs discuss these findings.

The observation findings indicated that the majority of participants only implement some of the five essential features of IBL as suggested by IBL. However, one aspect that is not clear from observation alone is whether the teacher intentionally used IBL approaches, or whether, where these were observed, they were unintentional uses of IBL strategies. In approximately a quarter of the lessons, none of the five essential features of IBL were observed. Also, in 27% of the observed lessons, just one or two features of IBL were presented. In only 7% of the observed lessons were all five essential features of IBL noted. These findings suggest that holistic and sustained IBL is uncommon in the Saudi schools and that the reform initiative was not implemented as intended. This finding is in keeping with previous observational studies (e.g., Capps & Crawford, 2013; Cook et al., 2015; Ozel & Luft, 2013), which showed that teachers often do not fully implement the features of IBL as suggested by NRC (2000). Because some features of IBL were more prominent in the observed lessons than others, each feature will be discussed separately.

9.4.1. The Feature of 'Learners Are Engaged by Scientifically Oriented Questions'

The observation data showed that the feature of 'learners are engaged by scientifically oriented questions' was noted in 42% of the observed lessons. Although the interview and survey questionnaire findings showed that teachers frequently reported 'posing questions' in their understandings of IBL, the practice of most of the observed teachers did not match what has been cited in NRC (2000) regarding this feature of IBL. To illustrate, teachers asked their students many questions in the observed lessons, but they rarely asked scientifically oriented questions that require investigation. For instance, teachers asked many questions to engage students in the lessons or to assess students' prior knowledge. These kinds of questions were not counted because they do not meet the criteria of the first feature of IBL which requires a scientific question to be investigated. This finding indicates that teachers have a lack of understanding about the process of IBL. This finding is consistent with Akhter (2013) who found that most teachers use questions in order to find out prior knowledge instead of involving students in scientific investigations.

The observation data showed that when the feature of 'learners are engaged by scientifically oriented questions' was observed in the classrooms, it was in a very teacher-centred direction. This finding is consistent with Cook et al. (2015), Houtz (2011), Leonard et al. (2011), and Ozel and Luft (2013) in which teachers take control over the questions and students are given little opportunity to formulate and pursue their own questions. Hogan and Berkowitz (2000) indicate that teachers have a concern that students may not know how to ask appropriate questions. Prior research highlights the difficulties that students face in formulating proper questions which focus on the intended content (Edelson, Gordin, & Pea, 1999; Krajcik et al., 1998; Singer, Hilton, & Schweingruber, 2006). For example, Krajcik et al. (1998) found that students did not choose questions "based on consideration of their scientific merits" (p. 342). They suggested that students' lack of experience in IBL may affect their choice of questions, and teachers' focus on learning subject content could reduce students' opportunities to formulate their own questions. Nevertheless, Bielik and Yarden (2016) found that students' ability to ask worthy questions is a skill which can be developed. Furthermore, Houtz (2011) indicates that students need to practise asking questions in order to develop this skill. Therefore, teachers may need a professional development programme in order to develop questioning skills, and students need guidance in order to effectively ask relevant questions.

The observation findings showed that the sub-feature of 'teacher engages learners in planning investigation' was only observed in one lesson which could indicate that Saudi science teachers rarely engage students in designing and planning investigations. This finding confirms the interview and the survey questionnaire findings which showed that the feature of 'planning investigations' was absent from teachers' perceptions of IBL in the qualitative data. A possible explanation of this result could be that all activities and their steps are provided by MOE, therefore, teachers and students follow 'cookbook activities'. However, this finding is inconsistent with Cook et al. (2015) and Leonard et al. (2011) who found that the feature of 'teacher engages learners in planning investigation' was presented in more than half of the lessons in their respective studies. This might be because the studies of Cook et al. (2015) and Leonard et al. (2011) involved teachers who were under a training program. Therefore, their sample might be more prepared to use IBL than the sample of present study or they might be more compliant (eager to do the right thing and to please their trainers). Another explanation is that both studies (Cook et al., 2015; Leonard et al., 2011) were conducted in the United States where IBL has been emphasised and practised for a long time, while IBL is relatively new in the Saudi context; it is also possible that there is less direction from curriculum authorities about lesson activities in the United States than in Saudi Arabia, which would give American teachers greater agency.

9.4.2. The Feature of 'Teacher Helps Learners Give Priority to Evidence'

The observation findings showed that the feature of 'teacher helps learners give priority to evidence' was the most common feature of IBL presented in the classrooms which was observed in 69% of the science lessons. This result can be supported by the interview and questionnaire data which showed that researching, collecting data, and making observations were frequent themes in teachers' definition of IBL. It is apparent that teachers consider the process of collecting data or evidence as an important component of learning and teaching science. It is also possible that this feature of IBL is more clearly indicated in the Saudi science textbooks than the other features of IBL. This explanation is supported by Aldahmash et al. (2016) who found that the feature of 'teacher helps learners give priority to evidence' was the most representative feature of IBL in the Saudi middle school textbooks. Therefore, it is not surprising that this feature of IBL was more prominent in the observed lessons than the other features of IBL since Saudi teachers have to follow the prescribed textbooks. The finding of the current study is consistent with Cook et al. (2015), Leonard et al. (2009), and Leonard et al. (2011) who found that the feature of 'teacher helps learners give priority to evidence' was one of the most prominent features in the teachers' practice in the classes that they observed.

The present study also found that the feature of ‘teacher helps learners give priority to evidence’ was usually teacher-directed. In fact, the decision of what constitutes evidence was very often up to the teachers. Additionally, teachers often provided a specific direction on how data were to be analysed. A possible reason for teachers’ reluctance to implement student-directed data analysis in their teaching is that teachers might not think that their students have the necessary skills (Asay & Orgill, 2010). Furthermore, the present study found that school textbooks were the main source of collecting evidence or data while other sources such as books and the internet were not used in observed lessons. This suggests that students might not be given the opportunity to have self-initiative to use a variety of sources in their learning process.

9.4.3. The Feature of ‘Learners Formulate Explanations and Conclusions’

The observation data showed that the second most noticeable feature of IBL in the classes was ‘learners formulate explanations and conclusions’ which was observed in 64% of the science lessons. This finding seems to support the interview and questionnaire data which showed that the theme of ‘deducing and drawing conclusions’ was one of the recurrent themes in teachers’ answers to the definition of IBL. A possible explanation could be that this feature of IBL is also well presented in Saudi science textbooks as noted by Aldahmash et al. (2016) who found that the feature of ‘learners formulate explanations and conclusions’ was widely presented in the middle school science textbooks’ activities. This finding seems to be consistent with the study of Cook et al. (2015) who also found that the feature of ‘learners formulate explanations and conclusions’ was observed in nearly half of the lessons. However, the finding of the present study is inconsistent with Ozel and Luft (2013) who found that the feature of 'learners formulate explanations' was rarely presented in their observed lessons. One possible explanation for this difference is that the study of Ozel and Luft (2013) involved early career teachers during their first year teaching while the present study involved teachers with different rages of experiences. Also, contextual differences between the present study and the study of Ozel and Luft (2013) may play a role in such distinctions.

The feature of 'learners formulate explanations and conclusions' was observed in teachers' practice although it was rarely mentioned by teachers in their descriptions of IBL activities in the qualitative data. Furthermore, none of the participants indicated in the interviews that they use this feature of IBL in their descriptions of IBL activities in the classroom while it was evident in their practice. This finding indicates that teachers' practice of IBL is not always consistent with their self-reports of IBL implementation, and that might be attributable to inadequate understandings of the nature of IBL.

9.4.4. The Feature of 'Learners Evaluate the Explanations in Light of Alternative Explanations'

The observation data showed that the feature of 'learners evaluate the explanations in light of alternative explanations' was only observed in two teachers' classes. Also, this feature of IBL was absent from teachers' perceptions of IBL in the qualitative data. Similar results have been reported in other studies (Blanchard & Sampson, 2017; Cook et al., 2015; Ozel & Luft, 2013) which found that the feature of 'learners evaluate the explanations in light of alternative explanations' was rarely used in the classrooms. Also, Chabalengula and Mumba (2012) and Kang et al. (2008) found out that the feature of ‘learners evaluate the explanations in light of alternative explanations’ was rarely used by teachers to characterise IBL. It is possible that the rare use of this feature of IBL is related to teachers’ pedagogical knowledge or teachers’ content knowledge (Crawford, 2000). For instance, if the teachers had inadequate knowledge of the science content and were unaware of potential alternative explanations, it would be challenging for those teachers to assist their students to connect their conclusions or explanations with accepted scientific knowledge. This finding implies that professional development programs that aim to improve teachers’ practice of the IBL feature of ‘learners evaluate the explanations in light of alternative explanations’ may be needed.

9.4.5. The Feature of ‘Learners Communicate and Justify Their Proposed Explanations’

The observation data showed that the feature of ‘learners communicate and justify their proposed explanations’ was presented in 47% of the observed lessons. However, this feature was absent from teachers’ perceptions of IBL in the qualitative data. This finding indicates that even though some features of IBL are absent from teachers’ perceptions of IBL, they might still be evident in teachers’ practice. This finding might also indicate that teachers may find difficulty in articulating, as distinct from enacting, IBL. Furthermore, this finding underscores that classroom observation as a data collection method is an important tool to investigate teachers’ implementation of IBL.

The finding of the present study is consistent with Cook et al. (2015) in which the feature of ‘learners communicate and justify their proposed explanations’ was observed in slightly fewer than half of the observed lessons. However, the finding of the present study is inconsistent with Ozel and Luft (2013) who found that the feature of ‘learners communicate and justify their proposed explanations' was rarely observed in teachers' practice. This discrepancy could be because the study of Ozel and Luft (2013) only involved junior secondary science teachers in their first year of teaching while the present study involved science teachers from different ranges of experiences and school levels. Also, the present study only involved two junior science teachers in the observations, and it was found that those two teachers did not implement the feature of 'learners communicate and justify their proposed explanations' in their observed lessons. This finding supports Ozel and Luft's (2013) observation that junior science teachers are unlikely to implement this feature of IBL. However, further research might be necessary to confirm this result.

9.4.6. Relationship Between Teachers' Knowledge and Implementation of IBL

The present study found that there was no association between teachers' knowledge of IBL and their practice. This result is aligned with the results of the study by Saad and Boujaoude (2012). However, this outcome is contrary to that of Capps and Crawford (2013) who found a positive relationship between teachers' knowledge and practice related to IBL. They noticed that teachers with robust views of IBL were more likely to teach science as inquiry while teachers with limited views of IBL were less likely to teach science as inquiry (Capps & Crawford, 2013). This discrepancy between the present study and the study of Capps and Crawford (2013) could be attributed to the different environments in which the two studies were conducted. The study of Capps and Crawford (2013) involved a group of highly motivated teachers and the researchers claim that their participant teachers could represent a best-case scenario of their knowledge and practice.

In addition, Capps and Crawford (2013) indicate that those teachers in their sample selected some of their better lessons to be observed. Therefore, it is possible that the participants in the study of Capps and Crawford (2013) demonstrated more IBL practice than the participants of the present study.

9.4.7. Teachers' Reports of the Implementation of IBL

The current study found that teachers had a tendency to report highly frequent use of IBL. This finding is consistent with prior research which showed that teachers tend to self-report regular use of IBL (Alhendal et al., 2016; Marshall et al., 2009; MASCIL, 2014). Abd-El-Khalick et al. (2004) articulate that teachers may claim that they use IBL in their practice; however, when those teachers are asked to describe their implementation of IBL in the classrooms, they often provide a set of activities that might be inconsistent with the notion of IBL. This suggests that science teachers may use different teaching styles even though they are trying to apply the same approach in a single curriculum (Abd-El-Khalick et al., 2004). Also, the present study found that most teachers reported highly frequent use of IBL despite their lack of knowledge about IBL. This result is consistent with the study by Capps et al. (2016), in which teachers who have inadequate knowledge about IBL tended to overrate and overestimate their use of IBL. The present study also compared between teacher self-reports about the frequency of use of IBL and their actual practice and found that teachers often think or claim that they implement IBL while in reality they may not be doing so. The issue of overestimating the use of IBL may result from the teachers' consideration of non-inquiry activities as inquiry activities. Furthermore, it possibly happens due to teachers' understandings that IBL is a sign of any form of active learning. It is also possible that the issue of overestimating the use of IBL may occur due to acquiescence bias which could be motivated by teachers' understandings that IBL is expected to be implemented.

This study found that some teachers indicated in the interviews and survey questionnaires that they use IBL in every lesson but their descriptions of the manner of implementing IBL and their observed practice did not reflect an IBL lesson. In contrast, some teachers reported in the interviews that they did not implement IBL while the observation data showed that they implemented the five essential features of IBL as suggested by NRC (2000). The mismatch between teachers' statements and their actual use suggests that self-reporting measurement about the frequent use of IBL might not provide accurate results since inadequate knowledge about IBL among teachers would make them likely to misreport their frequent use of IBL. However, self-reporting measurement about the frequency of using IBL could be a useful tool to identify possible gaps between what teachers think and what they actually do, especially when using other collection methods as was the case in the present study.

This study found that 59% of the interview sample indicated that they used IBL in the observed lessons. However, based on the observation data, 31% of the 59% scored zero across all six STIR categories. So, none of the five features of IBL was observed in their respective lessons. This result suggests that there was a mismatch between what teachers' think and what they are actually doing. This may occur due to misunderstanding of IBL practice. To illustrate, some teachers thought that they implemented IBL because they asked students many questions. Also, T9 indicated in the interview that "I used IBL in the observed lesson" even though he said, "I have no idea about IBL". The inconsistency between teachers' self-report of frequent use of IBL and their actual practice indicates that a possible gap exists between what teachers think and what they practise. This may serve as an obstacle to transforming teaching practice towards IBL and implementing the new reform in the Saudi classrooms. If the teachers think that they are implementing the reform initiative (as the present study found that most teachers reported regular use of IBL as suggested by NRC), then they would not be motivated to change their teaching practice.

The findings of the present study showed that the proportion of participants who believed that they always implement IBL in their teachings was higher in the interviews (40%) than the questionnaire (15%). Also, none of participants said "I never use IBL" in the interviews compared to 6% of the questionnaire sample. These differences may be due to the nature of data collection methods. For example, teachers may feel more candid in the anonymous online questionnaire than in the interviews. Also, this result may be because in the face-to-face interviews teachers may feel that they are under pressure to provide socially acceptable answers more than in the online questionnaires.

9.4.8. Teachers' Perceptions of their Role in IBL Lessons

The interview findings showed that almost all teachers agreed with one aspect of IBL: that it is a learner-centred approach where the students become more involved in the learning process, while the teacher adopts a role similar to being a facilitator or guide. This conception is in alignment with the new reform vision in Saudi Arabia and the NRC (2000) document. It seems that the participants, in general, were aware of their expected role in the curriculum reform. However, the observation findings indicated that teachers' practice is very structured and teacher-centred. This is another indication that there is a conflict between teachers' statements and their actual practice. Also, it indicates that the implementation of the new reform in Saudi Arabia is not proceeding as intended by the policy makers. Although previous studies found that teachers tend to implement IBL in a teacher-centred direction (e.g., Capps & Crawford, 2013; Cook et al., 2015; Karaman, 2007), the present study found that there is a gap between teachers' statements about their role in IBL lessons and their practice. This gap might be arising from the teachers' thinking that their role as facilitator is to provide students step-by-step procedures. Another possibility might be that although teachers are willing to implement an open inquiry and student-centred teaching strategy, they find practical difficulties in implementing such an approach. The teachers in the present study indicated several challenges which prevented them from implementing IBL. The next section will discuss these challenges in more detail.

9.4.9. Summary of the Discussion About Teachers' Implementation of IBL

The observation data showed that teachers' practice was very structured or teacher-directed. Also, none of the participants involved students in an open inquiry. This result matches those observed in earlier studies (Capps & Crawford, 2013; Cook et al., 2015; Karaman, 2007). The Saudi's MOE emphasises that the philosophical basis on which the adopted textbooks were built is to provide multiple opportunities for students to practise scientific inquiry at its various levels: structured, guided, and open. However, teachers' practice tends to be structured or teacher-directed. This indicates that a misalignment might exist between teachers' implementation and the ideals of the reform expectation. Furthermore, this finding indicates that the traditional teaching method is still dominant, and teachers continue to maintain control of the learning process in Saudi science classrooms. The complexity of using IBL, which places a high demand on teachers, might be an important reason for the rare implementation of IBL in classrooms (Crawford, 2000). Fullan (2007) emphases that the more complex an educational change, the more difficult it will be to implement.

Although the participating teachers appeared to have a sense that IBL is a learner-centred approach where the students become more involved in the learning process, their practice left little room for students' autonomy in the learning process. This finding implies another discrepancy between teachers' perceptions of IBL and their actual practice. A possible explanation of teachers' tendency to use direct instruction could be that teachers might have a concern to lose control over the classroom when using student-directed activities. Such a concern might prevent science teachers from involving student-centred activities or open inquiry (Baker, Lang, & Lawson, 2002). Another possible explanation could be that teachers might have inadequate pedagogical knowledge about the process of different levels of IBL as the interviews and questionnaire data showed that only a few teachers mentioned different levels of IBL such as open and guided inquiry. It is also possible that teachers use direct instruction because they do not think that their students have the required skills to be taught in a learner-centred way. This explanation is supported by the interviews and questionnaire data which showed that some teachers indicated that students’ lack of ability is an obstacle to IBL implementation.

Generally speaking, the interview, questionnaire, and observation data about teachers’ implementation of IBL could imply that the majority of participants did not demonstrate robust IBL science pedagogy. In most cases, there was little or no evidence of the five essential features of IBL as suggested by NRC (2000) in teachers’ practices in the classrooms. Additionally, the amount of student-directed IBL activities was fairly low. These findings suggest that professional development might be required to support Saudi science teachers to understand the various components of IBL and appropriate ways of using them. Powell and Anderson (2002) argue that the successful implementation of new curriculum materials requires transformative professional development that takes into consideration teachers’ existing knowledge and ideas about science instruction as well as their instructional contexts.

It is possible that the Saudi context would have been suitable to take gradual transformation that facilitated the understanding of the teachers’ expected role and the students’ motivation to get involved in the class activities and become an active participant in the learning process. This might have changed the teachers’ prevailing perception that the students would have become capable of actively participating in the learning process, and the teachers would not necessarily have lost control of the classroom or the learning process that had remained their responsibility.

9.5. Discussion of Research Question 4: What Are Saudi Science Teachers' Perceptions of the Challenges That Are Faced in Trying to Successfully Implement IBL?

One of the aims of the present study was to find out teachers' perceptions about the obstacles to using IBL. Although the participants held positive views towards IBL, they reported several factors that constrain them from enacting IBL such as lack of resources, large numbers of students in classes, heavy teaching loads, students' lack of ability, and heavy curriculum content. The following paragraphs discuss these findings.

9.5.1. Lack of Resources

More than half (55%) of the interviewed teachers reported that lack of resources is a major obstacle to implementing IBL. Also, the survey questionnaire finding conforms to the interview result which showed that 44% of the participants reported that 'lack of resources' is a major challenge of using IBL. Teachers in the interviews provided more details about the resources required, including materials, equipment, laboratory facilities, and technology. Previous studies highlighted that a shortage of adequate resources is a major obstacle to implementing IBL (e.g., Anderson, 2002; Fitzgerald et al., 2019; Gillies & Nichols, 2015; Ramnarain & Hlatswayo, 2018; Zhang et al., 2005). The NRC (2000) acknowledges that "nothing interferes with inquiry-based teaching more than lacking an adequate supply of instructional materials" (p.149). So, it is necessary that Saudi schools are provided with adequate resources including materials and equipment in order to facilitate the implementation of the new reform. Another possibility that could compensate for some forms of resource limitation might be to use professional development to upskill the teachers so that they can produce good resources of their own. As noted by Luvanga and Mkimbili (2020) and Mkimbili, Tiplic, and Ødegaard (2017) the implementation of IBL with lack of resources can be facilitated by well-trained and motivated teachers.

Some teachers might think that lack of resources is an obstacle to IBL because they perceive that IBL is only about doing experiments or practical work. The findings of the present study revealed that some teachers thought that IBL mainly depends on doing experiments or hands-on activities, therefore, it requires different materials and equipment (section 8.2.1). For instance, T3 commented on IBL challenges that "inadequate laboratories at schools hinders us from doing experiments". So, linking IBL to practical work might lead to the assumption that IBL requires multiple specific materials and equipment.

It appears that some teachers might not implement IBL because they think that IBL depends on the availability of materials and equipment. However, it seems that the teachers are either overlooking or fail to appreciate that some aspects of IBL such as engaging students in scientific oriented questions can be promoted without much equipment as well as through using, for example, the internet and public libraries.

9.5.2. Large Numbers of Students in Classes

Another issue that was reported by teachers is the large number of students in classes. 40% of the interviewees reported that the large number of students in the class prevents them from using IBL. Also, the survey questionnaire findings showed that approximately 64% of participants categorised the statement 'the large number of students in the class' as either a major or a large challenge of using IBL. It is possible that participants considered the large number of students in the class as an obstacle to use IBL due to classroom management issues. For example, some teachers indicated that the large number of students in the class creates a management issue and makes it difficult for students to move inside the classroom. This finding is consistent with the literature which showed that the large number of students and classroom management issues prevent teachers from implementing IBL (Davis et al., 2006; DiBiase & McDonald, 2015; Kim et al., 2013; Luvanga & Mkimbili, 2020; MASCIL, 2014). Also, some teachers in the current study not only reported the large number of students in the class, but also the small space in the classroom. Davis et al. (2006) argue that teachers' concern about classroom management issues can prevent teachers from implementing inquiry-oriented reform.

However, the interview data revealed that some teachers appeared to have a misconception about IBL which could lead to such an assumption. For example, T6 reported that "the most difficult thing is the large number of students in the class which may become a barrier. For example, I cannot pose a question to every student because it takes time and I have to cover the curriculum". So, T6 apparently thought that every student should be asked separately in IBL lessons. Also, some teachers claimed that the implementation of IBL in a classroom with a large number of students could cause chaos and teachers may lose control. However, Llewellyn (2013) and Wilcos et al. (2015) articulate that one of the common myths about IBL is that teaching science through inquiry is chaotic. Llewellyn (2013) notes that although classroom management is important in IBL lessons, an active role of students in the classroom should not be linked to chaos. IBL requires an active role of students more than in the traditional classroom, and as a result of this change teachers may feel they are losing control. Bell and Gilbert (1996) highlight that teachers who are new to IBL often think that the classroom is not under their control when students are moving across the room. Therefore, in order to establish IBL environments, it is necessary for teachers to be supported to accept the changes in their role and the culture of the classroom (Llewellyn, 2013).

9.5.3. Heavy Teaching Load

26% of the interview sample indicated that heavy teaching loads and busy schedules prevent them from implementing IBL. Time constraints have been widely reported in the literature as barriers to teachers' use of IBL (e.g., Dai et al., 2011; Fitzgerald et al., 2019; Gillies & Nichols, 2015; Gutierez, 2015; Kim et al., 2013; MASCIL, 2014; Ramnarain, 2016). This is due to several factors. Firstly, some teachers reported in the interviews that IBL requires more preparation time in comparison with the lecture-style teaching and as a result of heavy workload they do not have time to prepare for IBL. Therefore, teachers may feel that teaching science through the traditional way is easier for them. This is also supported by the survey questionnaire findings which showed that nearly 40% of the participants rated the statement 'it requires too much preparation time' as a large or major challenge to implementing IBL. This result is consistent with Gutierez (2015) and Dobber et al. (2017) who found that teachers may be reluctant to implement IBL reform for the reason that it requires considerable time to prepare. Also, Long and Bae (2018) found that heavy teaching load resulted in lack of time to prepare IBL lessons.

Some teachers also indicated in the interviews that heavy teaching load prevents them from implementing IBL because it negatively affects their performance, and they perceive that IBL requires a high mental effort and concentration. This finding is in alignment with Brand and Moore (2011) who found an inverse relationship between teachers' self-efficacy for IBL and workload. So, one implication of this result is that the MOE in Saudi Arabia might need to reduce teachers' workload in order to help them to implement IBL. In other words, teachers could be assigned to teach appropriate classes that leave them time during the day when they can organise and prepare their lessons. This will potentially maintain a work-life balance that will not cause any burnouts to the teachers. Also, teachers may need to be involved in professional development programs to help them effectively manage their workload, for example, by developing greater efficiency in the planning of IBL.

9.5.4. Heavy Curriculum Content and Lack of Time

Another factor that was perceived by the teachers as a barrier to implementing IBL is heavy curriculum content. 22% of the interview sample indicated this issue. Also, 67% of the survey questionnaire sample rated the issue of heavy curriculum content as a large or major challenge to implementing IBL. This finding is in line with the results of DiBiase and McDonald (2015), Fitzgerald et al. (2019), Kim et al. (2013), and Ramnarain and Hlatswayo (2018). In Saudi Arabia, the teachers are expected to cover all curriculum content and they should cover all topics in the science textbooks established by the MOE during the school term to prepare students for the next level of schooling. Some teachers in the present study reported that it is difficult for them to adequately deliver the curriculum content if they use IBL due to the limited time of the classroom. Teachers' perceptions that IBL is a time-inefficient way of covering the science curriculum have also been reported in the literature as an obstacle to IBL implementation (e.g., Gutierez, 2015; Kim et al., 2007). To bridge this gap, the MOE in Saudi Arabia might need to reduce the amount of curriculum content or allocate teachers more time to implement IBL in the classroom.

One of the aims of science education reform and IBL implementation in Saudi Arabia is to develop students' abilities and skills to gain a deep understanding of science content (section 2.6). However, this aim is thwarted if teachers focus on covering the curriculum content instead of conceptual understanding. Researchers (e.g., Curran & Kitchin, 2019; Schwartz, Sadler, Sonnert, & Tai, 2009) have shown that focusing on breadth of content coverage rather than depth of understanding results in a superficial understanding of science topics. Indeed, IBL takes more time than traditional teaching. Teachers may deliver a great amount of information by using a typical lecture. However, there is a difference between actual learning and covering curriculum content. Many studies (e.g., Bruder & Prescott, 2013; Ibrohim, Sutopo, Muntholib, Prihatnawati, & Mufidah, 2020) found that students taught by IBL tend to have a deeper and greater understanding of science content than students taught through traditional teaching. So, the development of higher-level thinking skills and the engagement of students in IBL experience are skills that should be practised and developed over time. Also, the MOE should decide what knowledge is most important to allow time for in-depth learning. Therefore, an appropriate balance between depth and breadth of coverage in relation to the desired outcomes of students' learning should be clearly specified in the curriculum (National Research Council, 2002).

9.5.5. Students' Lack of Ability and Motivation

Some teachers in the present study reported that students' lack of ability and motivation serve as a barrier to implementing IBL. Those teachers explained that students' lack of necessary skills such as reading, writing, and critical thinking skills prevent them from implementing IBL. While the studies of Kim et al. (2013) and Chan (2010) found a similar issue among primary school teachers, the current study found the issue of students' lack of ability in both primary and high school teachers. The findings of the present study suggest that not only do primary school teachers face the issue of students' lack of ability when implementing IBL, but also high school teachers may experience this challenge. One of the main aims of the implementation of IBL in Saudi Arabia is to develop students' critical thinking skills. However, some teachers in the current study reported that they do not use IBL because of students' lack of critical thinking skills. This finding indicates that a conflict might exist between the MOE objectives and teachers' perspectives. Teachers are expected to develop students' abilities through the use of IBL, but the teachers expect the students to know their role in IBL. However, some teachers reported in the interviews that IBL is more appropriate for students with high academic levels. Llewellyn (2013) reported that a common myth about IBL is that IBL is for students with high academic levels. However, NRC (2000) argued that IBL can be used across all students' levels, although the complexity of necessary abilities to do IBL increases from kindergarten through grade 12. Also, several researchers have demonstrated that IBL can increase students' achievement and develop the level of low-achieving students (Borovay, Shore, Caccese, Yang, & Hua, 2019; Kahle, Meece, & Scantlebury, 2000; Marx et al., 2004; Rocard et al., 2007; Scruggs, Mastropieri, Bakken, & Brigham, 1993).

Also, some teachers in the current study do not feel they would be able to include IBL into their teaching because of their view that their students lack motivation to learn science. Perhaps those teachers struggled to create an appropriate environment for IBL in the classroom. This explanation is supported by the observation data which showed that there was a little use of IBL in the classrooms. Anderman, Andrzejewski, and Allen (2011) reported that teachers' practice is positively correlated with students' motivation to learn. Furthermore, the literature has found that IBL increases students' interest toward learning science (Avery & Meyer, 2012; Borovay et al., 2019; Potvin, Hasni, & Sy, 2017; Rocard et al., 2007; Wang, Wu, Yu, & Lin, 2015). It might be useful for the policy makers to help teachers to see some demonstration that IBL can be motivating to science learners in the Saudi context.

9.5.6. Other Obstacles to IBL Implementation

T5 reported in the interview that the time slot for the science lesson affects the implementation of IBL. T5 cited that "… the seventh lesson at the end of the day is not the same as … the first and second lessons of the day because students tend to have better attention in the morning than the afternoon time". So, this result suggests that the timeslot allocated for the science lesson may play a role in implementing IBL. This issue has not previously been described in the literature. A further study with more focus on the impact of the allotted time slot for the lesson on teachers and students' use of IBL is therefore suggested.

9.5.7. Summary of the Discussion About Teachers' Perceptions of IBL Challenges

Science teachers indicated various obstacles which, in their view, make the consistent practice of IBL more problematic for them. The literature has reported two main groups of factors that prevent teachers from implementing IBL: external factors (e.g., time constraints and lack of resources) and internal factors (e.g., lack of content and pedagogical knowledge). The obstacles to IBL implementation reported by the teachers in the current study correspond mostly to external factors. So, most issues reported by the teachers are primarily associated with the characteristics of the current education system. A possible explanation of teachers' attribution of the obstacles of IBL to external factors is that they might consider the current education system to be unsupportive of IBL implementation. Deboer (2002) stresses that "in the present environment of curricular and pedagogical reform, a tension exists between the ideals of student-centred learning and the realities of the classroom" (p.411). So, the education system could create an environment that makes the new standards difficult and presents challenges to their implementation (Deboer, 2002). Teachers' adoption of their new role in the science reform appears to be difficult without making additional changes in the current education system in Saudi Arabia. As NRC (1996) acknowledges, "to attain the vision of science education described in the Standards, change is needed in the entire system. Teachers are central to education, but they must not be placed in the position of being solely responsible for reform" (p.27). The educational system's inconsistency with the ideas of science education reform may offer teachers rationalisations of their limited implementation of the policy change.

Chapter 10: Conclusion

10.1. Introduction

The main aim of the present study was to investigate Saudi science teachers' perceptions about IBL across the three school levels (primary, middle, and high). More specifically, the present study attempted to answer the following questions:

1. How do Saudi science teachers understand inquiry-based learning?
2. What are Saudi science teachers' beliefs about inquiry-based learning?
3. What are Saudi science teachers' perceptions of the challenges that are faced in trying to successfully implement inquiry-based learning?
4. How do Saudi science teachers implement inquiry-based learning in the classroom?

A mixed methods approach was adopted, and appropriate types of data collection methods (observations, interviews, and online questionnaires) were used to investigate the research questions.

This chapter begins with a summary of the main findings in relation to the research questions. This is followed by discussion of some of the implications of the findings for practical purposes, including implications for science teachers at all school levels and for policy makers. Also, this chapter provides a discussion of the limitations of the present study. Finally, recommendations and directions for further research are proposed.

10.2. Summary of the Main Findings

The research questions have been answered and discussed in detail in Chapter 9. The purpose of this section is therefore to highlight the key findings of the study in the light of the research questions.

10.2.1. How Do Saudi Science Teachers Understand IBL?

The findings of the present study clearly indicate that science teachers who participated in the current study held different understandings about IBL and some of these understandings are inconsistent with the adopted definition of IBL in this study that was based on NRC's (2000) definition. The participants associated IBL with a number of characteristics, such as researching, deducing, discovering, posing questions and/or problems, carrying out experiments, making observations, and extracting students' prior knowledge. However, the term 'researching' was the most reported term in the qualitative findings about teachers' definition of IBL. More than a quarter (26%) of participants who provided their own definition of IBL indicated 'researching' when defining IBL (section 5.2.4.1.1). Also, certain aspects of IBL as defined by NRC (2000) were not mentioned by any participants, such as planning investigations and communicating the results.

Additionally, most participants appeared to have inadequate knowledge about IBL (sections 5.2.1 and 5.2.2). Most participants did not have well-structured knowledge about IBL; rather they used a very broad explanation of IBL such as 'researching' and 'discovering'. Some participants had a narrow understanding of IBL such as posing questions and/or problems and doing experiments (section 5.2.4). Also, the present study found that only a minority of the participants (11% of the survey sample and 15% of the interview sample) appeared to have a good knowledge of IBL. A small proportion (8% of the surveyed participants and 4% of the interviewees) appeared to have no knowledge about IBL based on their explicit answers to the question 'how do you define IBL?'.

The survey questionnaire findings revealed that there was potential ambiguity in the understanding of IBL among the participants because the majority of respondents mapped non-inquiry activities onto inquiry activities, and they were unable to distinguish between inquiry and non-inquiry activities. Only 11% of the survey questionnaire sample were able to correctly recognise and distinguish all inquiry and non-inquiry activities (section 5.3).

One of the important findings to emerge from the present study is that there were statistically significant differences in teachers' understandings of IBL according to their teaching school levels. On the other hand, the present study did not find statistically significant differences in teachers' understandings of IBL according to their teaching experience and specialisations (sections 5.2.4 and 5.3.1). Also, the findings of the teachers own definitions of IBL showed that there was a statistically significant association with gender in the likelihood of regarding IBL as posing questions and carrying out experiments. These findings have not been found in the reviewed literature and may be specific to the Saudi context.

10.2.2. What Are Saudi Science Teachers' Beliefs About IBL?

Another key finding of the present study was that the participants held a strong positive attitude towards IBL as stated in NRC (2000) and the Saudi official documents (Sections 6.2 and 6.3). The participants reported in the interviews several reasons justifying their positive attitude towards IBL that include: IBL enhances students' understanding, IBL promotes self-directed learning, IBL develops students' abilities and skills, and IBL enhances psychological factors related to learning. Furthermore, the survey questionnaire findings confirmed the interview results which showed that the majority of participants either agreed or strongly agreed with all statements about importance and benefits of IBL as stated in NRC (2000) and the Saudi official documents. Although most teachers in the current study shared limited understandings and practice of IBL, they held a positive attitude towards IBL. This finding could suggest that a positive attitude towards the change is not sufficient for successful implementation of the reform initiative.

The present study also found that there were statistically significant differences in teachers' beliefs about IBL according to their teaching school levels and specialisations (section 6.3.1). Secondary school teachers were more positive about IBL than primary school teachers. Furthermore, teachers who are specialists in general science and those with non-science backgrounds were less positive about IBL. Moreover, chemistry specialist teachers' attitudes towards IBL were seen to be the most favourable of the other groups of teachers (biology, physics, general science, and non-science specialist). Taken together, these results suggest that teachers' beliefs about IBL varied across teachers' school levels and specialisations.

10.2.3. How Do Saudi Science Teachers Implement IBL in the Classroom?

Although the finding of the positive attitude of science teachers towards IBL was encouraging, teachers' actual practice of IBL in the classrooms was disappointing from the point of view of policy implementation. One of the important findings to emerge from this study is that IBL was rarely observed within classrooms, and the traditional method of teaching is still dominant in Saudi schools. The observation data indicated that teachers' practice was very structured and teacher-directed. In most cases, there was little or no evidence of the five essential features of IBL as suggested by NRC (2000). This finding indicates the existence of a gap between the policy makers and science teachers that hindered the successful implementation of the educational reform. This result was perhaps not surprising, since the implementation of educational reform is a complex process and requires significant time, consistent guidance, and ongoing support (Fullan, 2007). It appears that the science education reform in Saudi Arabia was adopted on the policy level, with the change of the science textbooks, but teachers' practice remained essentially unchanged.

Another key finding was that most teachers reported highly frequent use of IBL despite their lack of knowledge and observed practice of IBL. This finding may be attributed to the fact that teachers interpreted IBL differently. Also, the participants' overestimation of their use of IBL might be attributed to misconceptions about IBL, as the present study found that there was no association between the level of teachers' knowledge about IBL and their practice. This finding could suggest that self-reporting of the frequency of use of IBL might not provide accurate results. More importantly, it appears that the meaning of IBL was not sufficiently clearly introduced in the Saudi reform documents or appropriately received by the teachers. Therefore, most teachers in the present study reflected a lack of both understanding and implementation of IBL. The “clarity” of educational innovation is an essential element in the implementation process (Fullan, 2007); it is important for teachers to understand the meaning, the objectives, and the goals of a reform initiative in order to implement it successfully (Fullan, 2007).

The findings of the present study showed that the participants appeared to understand their role in the adopted curriculum as a facilitator or guide and that students play an active role in the learning process. Also, the teachers who participated in this study appreciated the importance of using IBL in teaching science. However, their appreciation of the importance of IBL did not translate to IBL implementation in the classroom. The gap between teachers’ statements and their actual practice might be due to the following reasons. Even though the MOE in Saudi Arabia provided teachers with new science textbooks, teacher’s guidebooks, and some workshops, most teachers appeared to feel that these efforts have not provided adequate impetus alone for the change. The participants conveyed their needs for professional development programs, as many of them reported in the interview that they have not participated in any of the MOE workshops. Also, the interview findings revealed that some teachers who attended particular workshops about the new science textbooks indicated their view that these workshops were inadequate in preparing them to use IBL. So, this highlights that it is important that teachers are provided with the necessary practical knowledge about IBL before asking them to implement associated reform.

The teachers also reported several factors that prevent them from implementing IBL which will be summarised in the next section.

10.2.4. What Are the Saudi Science Teachers' Perceptions of the Challenges That Are Faced in Trying to Successfully Implement IBL?

The present study explored many factors perceived by teachers as barriers to IBL implementation. Five major challenges were reported by teachers which are: lack of resources, the large number of students in the class, heavy teaching load, students' perceived lack of abilities, and heavy curriculum content. The findings of the current study provide valuable insights to both the policy makers in Saudi Arabia and the MOE to help them understand different factors that hindered the implementation of the reform initiative. If these factors that impede the implementation of the reform are not effectively dealt with by the MOE in Saudi Arabia, then it is more likely that the change will remain unsuccessful in achieving its goals.

This study found that there was a statistically significant difference in teachers' perceptions of the obstacles to using IBL according to their specialisations. This result indicates that teachers' perceptions about the challenges of IBL implementation are not the same across different specialisations. Based on the literature review completed in this research study, these findings have not been reported in the literature. So, it might be important for the policy makers to address the needs of different specialisations in the process of implementing IBL.

10.3. Implications and Recommendations of the Research

The findings of the present study offer several implications and recommendations for consideration in the domain of IBL, curriculum innovation, and teachers' change in science education. Therefore, this section presents the main implications and recommendations which arise from the study's findings for the policy makers, the MOE, and science teachers.

One of the main implications of the findings is that teachers' understandings of IBL might be an indication of IBL implementation in the classrooms. The findings of the present study suggest that most participants appeared to have inadequate understandings and use of IBL. So, teachers' limited understandings about IBL seems to be associated with poor practice of IBL in the classroom. It is, therefore, important for teachers to develop an adequate understanding of IBL to be able to implement it in the classrooms.

Teachers' misconceptions about IBL might be a major reason why IBL is not being implemented in accordance with Saudi MOE reform documents. The present study found that most teachers thought or claimed that they implemented IBL while the in-class observations data showed otherwise. Teachers' own understandings of IBL affect their reporting of using IBL. For example, some teachers in the present study thought that IBL is all about asking questions. As a result of this oversimplified understanding of IBL, those teachers believed that they fully implemented IBL in all lessons. This finding reflects what Fullan (2007) has termed "false clarity" which occurs when teachers interpret the reform in an oversimplified way. In contrast, some participants reported that IBL is about doing experiments or practical work. So, they did not use IBL regularly since the idea of doing experiments is not practicable for daily use in lessons. Accordingly, these misconceptions about IBL need to be rectified. Also, providing teachers with practical examples and models for IBL is essential to the success of its implementation.

Another important implication of the findings is that there is a clear gap in IBL knowledge dissemination between the MOE and teachers in Saudi Arabia. Almost half of the teachers who were interviewed reported that they developed their understanding of IBL from sources other than the MOE's guidance. This finding indicates that the MOE in Saudi Arabia needs to develop strategies to communicate more effectively with all the nation's teachers. If there is inadequate communication between the MOE and the teachers, then the outcome of the reform is likely to fail in achieving its goals. It is important for the policy makers and the MOE to ensure that the official guidance is accessible and uniformly disseminated to all teachers.

It appears that the MOE in Saudi Arabia did not succeed in involving teachers as stakeholders in planning the reform process or in considering their views about the implementation of the adopted science textbooks. This implies that it is important for the MOE in Saudi Arabia to create a network of cooperation with teachers which could establish a continuous feedback loop and bridge the gap between teachers and policy makers in any curriculum reform plan.

An implication of the findings of the present study is that teachers need to be engaged early in the planning stage of the curriculum reform and professional development programs that result in changes in teacher practices. The interviewed teachers in the present study expressed their need for professional development programs that support them to implement the reform. A noteworthy and unexpected result in the present study is that more than half of the teachers who were interviewed indicated that they never had the opportunity to attend any professional development program related to IBL. Even though some of the teachers attended a one-session workshop about the adopted science textbooks, they found these short workshops were inadequate for providing them with the necessary skills for implementing IBL. Teachers expressed their need for long-term professional development programs that provide them with practical examples, models and actual hand-on experience of IBL. So, the decision makers in Saudi Arabia may need to change or review the strategies intended for professional development programs. It is also suggested that instituting ongoing professional development programs that aim to enhance teachers' pedagogical content knowledge will ensure the intended outcome for the new policy or change that has implications for teaching practice. Furthermore, it is important for the policy makers to develop training programs that focus not only on the theoretical side of IBL but also on the practical side. Additionally, professional development programs should address the difficulties that teachers encounter when implementing IBL.

Another aspect that was raised by some teachers was that the one-session workshops were not designed to address the need of a specific group (e.g., school level or subject). For example, a teacher indicated in the interview that he attended a training workshop that was designed for all teachers' levels and subjects. He suggested that each school level and subject specific teachers should be provided with a tailored training program that focuses on their specific needs. Also, the findings of the present study revealed that teachers' perceptions of the meaning and challenges of IBL varied according to their genders, teaching school levels, specialisations, and experience. So, teachers' demographic characteristics should be taken into consideration when designing professional development programs.

Another implication of the current study is that a change of curriculum or textbooks alone would not guarantee the desired change in teachers' practice. Also, positive attitudes towards the reform initiative are inadequate to change teachers' practice. The results of the present study confirm the 'theory of planned behaviour' which suggests that positive attitudes alone do not result in action (Ajzen, 1991). "Behavioral achievement depends jointly on intention (motivation) and ability (behavioral control)" (Ajzen, 1991, p. 182). Although the participants in the present study showed a strong positive attitude towards IBL and its implementation, they reported many issues that hinder them from implementing the change. The major challenges that teachers perceived as an obstacle to IBL implementation included lack of resources, the large number of students in the class, heavy teaching load, students' lack of ability, and heavy curriculum content. These issues should be considered by the policy makers in order to achieve the intended outcome for the IBL reform or for any similar magnitude future change. For example, adequate resources that meet the requirements and demands of the adopted science textbooks should be provided to all schools. Without providing teachers with the necessary resources, such as materials and equipment, teachers will be unlikely to change their style of teaching, as evident in the present study. It appears that the initiation phase of the new reform in Saudi Arabia was given more attention than the implementation phase. Inadequate resources might indicate that the decision makers did not give necessary time for a development phase (Fullan, 2007). It is possible to think that the teachers' involvement in the entire process of planning and executing the reform initiatives could have led to the development of the necessary skills to effectively deal with IBL challenges. Another possible and complementary way to facilitate the implementation of IBL is to upskill the teachers through professional development so that they can effectively deal with the above-mentioned challenges.

Policy makers in Saudi Arabia should evaluate the appropriateness of the adopted science textbooks for implementation in schools. Policy makers should also evaluate the preparedness of schools and address any identified issues and any further issues that could arise during the implementation in schools. Teachers in the present study had a sense that the adopted science textbooks do not fit the current school system in Saudi Arabia. Teachers argued that the heavy content of the adopted science textbooks could not be covered within the school term if they were required to use only IBL; as a result, teachers continued using traditional teaching practices to deliver the complete content of the textbooks. So, time allocated for class sessions should be extended or the number of the topics to be covered in the adopted science textbooks should be reduced.

Assessment of students can play a vital role in implementing reform and changing teachers' practices (Millar, 2013), and it can drive practice if students, teachers, and schools are held to account for assessment outcomes - i.e., if the stakes are high. So, it is recommended that the policy makers in Saudi Arabia should modify the students' assessments system for science to be compatible with IBL. The reform might not be implemented successfully if there is no associated change in the way of students' assessments. Teachers are unlikely to change their teaching style and implement IBL if the assessment strategies have not been designed in a manner that is compatible with IBL. For example, if the students' assessments focus on content knowledge, rather than demonstrating inquiry skills and the deeper understanding of content that these can bring, teachers will tend to pay close attention to the content and the amount of students' knowledge of science concepts rather than to inquiry skills and deeper understanding of these concepts. So, teachers might not change their practices if they perceive that their teaching style is effective in delivering science content and their students' performance in exams is satisfactory. Given that assessment now is similar to how it was before the IBL reform, this would probably have inhibited teacher change. Further research could investigate the impact of student assessment strategies in science on teachers' implementation of IBL in Saudi Arabia.

Teachers also claimed that the adopted science textbooks are inappropriate for their students' perceived ability. This result suggests that it is important for the policy makers to implement a curriculum or textbook that is well matched to the students' level of attainment. The science textbooks in Saudi Arabia were adopted from a different context (American context) which might be inappropriate for use in the Saudi schools due to socio-cultural differences. This implies that socio-cultural differences should be given due consideration in adopting a curriculum or textbooks from a different context. Another possibility to overcome the issue of students' apparent lack of ability is to start training students on how to learn through IBL, especially in the early stages. This should be a part of the teaching in schools. So, students’ capacities as active learners are gradually developed, in support of IBL pedagogy.

Teachers also reported that classrooms are overcrowded, and they find it difficult to manage or control students while using IBL. The observation data also confirmed that student-teacher ratios were high. For example, the number of pupils in some observed lessons was between 40 to 50 students per teacher. So, it is important for the policy makers in Saudi Arabia to decrease the ratio of students per teacher for the desired outcome of active pedagogies such as IBL to be implemented. Alternatively, teachers might need to be supported by teacher assistants to help them in managing and leading the class: there are no teacher assistants in the current school system in Saudi Arabia.

Teachers also reported that lack of time and their heavy teaching loads serve as barriers to IBL implementation. Teachers argued that IBL requires greater effort and preparation time than traditional teaching practice. An implication of this is the possibility that the current education system in Saudi Arabi limits teachers' ability to implement IBL. So, it is worth highlighting that the authority in Saudi Arabia should review their policy and current school systems as well as considering the above-mentioned issues, in order to successfully implement the change to IBL in science education.

10.4. Contribution of the Present Study to Knowledge and Understanding

This thesis makes several noteworthy contributions to knowledge on teachers’ understandings, beliefs, and implementation of IBL. Firstly, the present study provides the first comprehensive investigation of Saudi science teachers' understandings, beliefs, and implementation of IBL. So, the richness of the data, which included classroom observations, interviews, and questionnaires lays the groundwork for future research into teachers' perceptions and implementation of IBL in Saudi Arabia or Middle Eastern countries since there is a lack of research in this field. Also, the findings of this study could benefit teachers, practitioners, and policy makers in Saudi Arabia and provide a picture of the current status of this science education reform. The findings of the present study could guide the policy makers in Saudi Arabia to take the necessary steps in order to enhance the integration of IBL in science classrooms.

The findings of the present study add to a growing body of literature on teachers' response to curriculum innovations and shed light on the multiple factors that influence teachers' implementation of IBL initiatives, especially in a top-down approach that relies on authority figures. This study contributes to knowledge by showing that the top-down approach of implementing IBL in classrooms is unlikely to succeed in achieving the desired objectives unless it is accompanied by other approaches, for example encouraging more bottom-up reform. This study showed that IBL was rarely observed within classrooms, and the traditional method of teaching is still dominant in Saudi schools. Also, this study showed that, in general, Saudi science teachers did not have well-structured knowledge about IBL, and their understandings of IBL were inconsistent with the policy documents. Both findings demonstrate the insufficiency of top-down policy reform alone.

The present study also addresses the gap in the literature by involving science teachers across three school levels. Published studies have focused on a specific school grade or level while the present study included different school levels. Therefore, the current study appears to be the first study to compare between teachers’ understandings and beliefs about IBL and their school levels (primary, middle, and high); it was found that teachers’ understandings and beliefs about IBL differed between teachers across different school levels. Furthermore, the present study addresses a gap in the literature by comparing teachers' understandings and beliefs about IBL according to their gender, teaching experience, and specialisation. This study found that science teachers’ perceptions about IBL differed according to their specialisations (biology, chemistry, physics, and general science).

The present study not only explored teachers’ attitudes towards IBL, but also the reasons behind their attitudes. Teachers reported in the interviews four reasons justifying their positive attitudes towards IBL, which are: IBL enhances students’ understanding; IBL promotes self-directed learning; IBL develops students’ abilities and skills; IBL enhances psychological factors related to learning. This finding adds to a growing body of literature on teachers’ beliefs about IBL.

This study provides an overview of the challenges that science teachers face in implementing IBL in their classrooms. The findings of the present study contribute to the literature which shows that the main barriers to IBL integration are due to lack of resources, the large number of students in the class, heavy teaching load, students’ perceived lack of abilities, and heavy curriculum content. Moreover, this study has highlighted factors that may affect IBL implementation which have not been found in the literature, such as the time slot allocated to the science lessons during the school day (section 8.2.6). This study confirmed that similar patterns of IBL perceptions, barriers, and implementation exist between Saudi Arabia and Western countries, although there are some important differences.

This study contributes to knowledge by comparing between teachers' statements and their actual practice of IBL, and showing that using self-reporting measurement of the frequency of use of IBL might not provide accurate results. Most teachers in the present study reported highly frequent use of IBL despite their lack of knowledge and observed practice of IBL. This finding may be attributed to the fact that teachers interpreted IBL differently, which is related to misconceptions about IBL. So, the present study demonstrated the value of using classroom observation as a data collection tool to investigate teachers' implementation of IBL and to find out if teachers' statements are in concert with their actions. Moreover, the present study developed a validated questionnaire instrument that can be used to measure teachers' perceptions and beliefs about IBL.

The present study systematically analysed the level of teachers' understanding of IBL by using five categories which were: no knowledge, uncertain knowledge, basic knowledge, fair knowledge, and good knowledge of IBL. The NRC's (2000) definition of IBL was adopted to analyse the level of teachers' knowledge of IBL. Therefore, this study provided an analysis framework for future research in relation to teachers' knowledge of IBL. Finally, the present study contributes to knowledge by examining the relationship between teachers' knowledge of IBL and classroom practice. This study revealed that there was no relationship between teachers' knowledge and their practice in the classroom related to IBL. Some teachers in this study represented good practitioners of IBL but could not necessarily articulate it. However, the present study found a positive association between teachers' understandings and beliefs about IBL. So, the findings of this study revealed that greater positivity is associated with a more accurate understanding of the nature of IBL. Hence, these findings add this insight to the literature in the field of IBL.

10.5. Limitations of the Study

Certain limitations to the present study need to be acknowledged. This study has only focused on science teachers' perspectives of IBL while other stakeholders such as policy makers, school principals, and students were not involved. The voices of other key stakeholders may provide important insights into the implementation of IBL in Saudi Arabia and allow for a comparison between teachers and other key stakeholders' perceptions of IBL.

Another limitation is that the number of non-inquiry activities statements on the scale of teachers' understandings of IBL in the questionnaire was two statements. So, it would have been better to include more than two non-inquiry activities to further investigate the extent to which teachers could differentiate between inquiry and non-inquiry activities. However, the interview results in the present study support the questionnaire findings.

The observation and interview sample was confined to 10 schools from different levels (primary, middle, and high) in Mecca city due to the logistics and authorisation process involved in multi-city data collection. Mecca city is urban (not rural), diverse (ethnically and economically), relatively affluent, well-connected, and cosmopolitan (with a variety of cultures, thought, and education levels). Therefore, the findings of the observation and interviews might be representative of a similar context within Saudi Arabia. However, it might not be quite representative of all Saudi educational contexts, e.g., small cities, towns, and rural communities. Including more schools and teachers in the observations and interviews from different cities and contexts in Saudi Arabia could expand the range and depth of the findings.

The number of female teachers in the observations and interviews were fewer than male teachers due to difficulties of arrangements with female schools. As indicated in section 4.5.1, the school system is Saudi Arabia is gender-segregated. So, access to female schools was not permitted to the researcher. However, this issue was minimised by recruiting a qualified female research assistant for the purpose of interviewing and observing female teachers, and by collecting responses from the online questionnaire.

The inclusion of classroom observations in the design of this study has added considerably to its methodological power. 45 lessons were observed, adding richness to the data from a perspective on classroom practice that is independent of the teachers' subjectivity and of any possible reporting biases. It is clear from these lessons that IBL is by no means comprehensively embedded in these teachers' practice. However, the sample is a small proportion of the total number of lessons taught by the study's teacher-participants over an annual cycle, and therefore provides only a snapshot. It is possible that the sample of 45 lessons is not fully representative of these teachers' practice, either individually or collectively. For example, it is possible that IBL practice is not evenly spread across a teacher's output, for example if some topics lend themselves to IBL approaches more than others. Empirical evaluation of this issue is beyond the scope of the present study.

The teachers in the present study gave more consideration to the external factors that hinder them from using IBL in classrooms (e.g., lack of resources, class size, and time restraints). However, they did not emphasise internal factors related to them that may affect their use of IBL (e.g., their lack of knowledge and understanding about IBL). This may affect the findings of the teachers' perceptions about IBL challenges, and their answers might be influenced by socially acceptable norms. In other words, teachers might have emphasised external factors in this study because it is socially undesirable to admit that they have a lack of understanding of what they are teaching. Furthermore, this may serve as an obstacle to transforming teaching practice towards IBL and implementing the new reform in Saudi classrooms. If the teachers believe that the obstacles to implementing IBL are not from their side, they may not make an effort to try to implement the reform and overcome the obstacles.

This study, however, did confirm that teachers have extensive knowledge of young people, and what is going on in their lives outside the classroom which may be impacting their engagement with traditional pedagogy. For example, a participant indicated that

> The benefit of IBL is that the student makes a conclusion at this time where massive technology innovation is going on. Unfortunately, many communities or students are not interested in what benefits them in their educational journey,

> but they are shifting toward games. So, it is an opportunity for teachers to practise such a strategy in order to make students feel a sense of happiness when they reach a result.

It seems from the teacher's response that the traditional mode of learning is generally not motivating to students while they enjoy being involved in interactive learning environments, especially nowadays where rapid pace of technological change is happening. This finding indicates that teachers’ voice is significant in understanding the culture that young people are living in and the changes that happen around them. Therefore, it is important for further research to explore what teachers know about young people in terms of the education process (e.g., the factors that motivate young people in education and the impact of technology on children's learning). It is also important for policy makers to engage in genuine dialogue with the teacher community, not just transmissive imposition of policy change.

10.6. Suggestions for Further Research

Because IBL is still in its early stages of implementation in Saudi Arabia, considerably more work needs to be done in this field. As a result of the findings of the present study, several areas should be considered in future studies. Firstly, the findings of the present study showed that most participants were unable to distinguish between inquiry and non-inquiry activities in the questionnaire. Also, some participants thought that IBL is any form of active learning. However, further research is recommended to closely look at how likely teachers can differentiate between IBL and other active teaching methods such as problem-based learning and discovery learning.

Secondly, participants in the present study claimed that IBL enhances and improves students' learning, but that students lacked the ability to engage in IBL. This necessitates that empirical studies should be undertaken to investigate the impact of IBL on students' achievements in the Saudi context. Thirdly, further research could investigate the effect of the time slot allocated to the science lessons on teachers' implementation of IBL. For instance, teachers' performance of IBL in the first school lesson may not be the same in the last school lesson. Therefore, a further study could examine the association between science lesson allocated times of the school day and teachers' performance of IBL.

Fourthly, it is recommended that additional research to be conducted to explore policy makers' perceptions of IBL and the processes undertaken to promote and support IBL implementation in Saudi Arabia. It would be interesting to compare the perceptions of policy makers and teachers about IBL. Comparing policy makers and teachers' perceptions of IBL and the reform initiative could reveal interesting results and help to bridge the gap between policies and practice.

Fifthly, although the present study investigated Saudi science teachers' perceptions of IBL using Arabic language (the findings are translated and presented in English), future research is recommended to further explore the Arabic terms that are used for IBL in the Saudi context and their conceptual relationships to the English terms and the Arabic translations of the English terms. This could enhance understanding of the ideas that these terms refer to and connect with in Arabic, in order to add an understanding of how IBL is conceptualised by teachers and/or policy makers in the Saudi context. Such research would be of relevance in other Arabic-speaking nations too, to explore the implications of a focus on IBL in science learning within Arabic cultural and linguistic traditions.

Finally, a further field study could assess teachers' implementation of IBL in the classrooms over an extended period of time such as one semester or one academic year. Also, future research might try to design a continuing professional development (CPD) intervention and explore whether that could be successful in supporting the implementation of IBL pedagogy by different groups of Saudi science teachers. Such studies may provide a more complete picture of teachers' practice of IBL in Saudi Arabia.

Appendices

Appendix A.1: Science Teacher Inquiry Rubric (STIR) Adopted from Bodzin and Beerer (2003)

	Learner Centered	⟵⟶			Teacher Centered
Learners are engaged by scientifically oriented questions.					
Teacher provides an opportunity for learners to engage with a scientifically oriented question.	Learner is prompted to formulate own questions or hypothesis to be tested. ☐	Teacher suggests topic areas or provides samples to help learners formulate own questions or hypothesis. ☐	Teacher offers learners lists of questions or hypotheses from which to select. ☐	Teacher provides learners with specific stated (or implied) questions or hypotheses to be investigated. ☐	No evidence observed. ☐
Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.					
Teacher engages learners in planning investigations to gather evidence in response to questions.	Learners develop procedures and protocols to independently plan and conduct a full investigation. ☐	Teacher encourages learners to plan and conduct a full investigation, providing support and scaffolding with making decisions. ☐	Teacher provides guidelines for learners to plan and conduct part of an investigation. Some choices are made by the learners. ☐	Teacher provides the procedures and protocols for the students to conduct the investigation. ☐	No evidence observed. ☐
Teacher helps learners give priority to evidence which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.	Learners determine what constitutes evidence and develop procedures and protocols for gathering and analyzing relevant data (as appropriate). ☐	Teacher directs learners to collect certain data, or only provides portion of needed data. Often provides protocols for data collection. ☐	Teacher provides data and asks learners to analyze. ☐	Teacher provides data and gives specific direction on how data is to be analyzed. ☐	No evidence observed. ☐

Science Teacher Inquiry Rubric (STIR) (continued)

Learners formulate explanations and conclusions from evidence to address scientifically oriented questions.					
Learners formulate conclusions and/or explanations from evidence to address scientifically oriented questions.	Learner is prompted to analyze evidence (often in the form of data) and formulate own conclusions/ explanations. ☐	Teacher prompts learners to think about how analyzed evidence leads to conclusions/explanations, but does not cite specific evidence. ☐	Teacher directs learners' attention (often through questions) to specific pieces of analyzed evidence (often in the form of data) to draw conclusions and/or formulate explanations. ☐	Teacher directs learners' attention (often through questions) to specific pieces of analyzed evidence (often in the form of data) to lead learners to predetermined correct conclusion/explanation (verification). ☐	No evidence observed. ☐
Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.					
Learners evaluate their conclusions and/or explanations in light of alternative conclusions/ explanations, particularly those reflecting scientific understanding.	Learner is prompted to examine other resources and make connections and/or explanations independently. ☐	Teacher provides resources to relevant scientific knowledge that may help identify alternative conclusions and/or explanations. Teacher may or may not direct learners to examine these resources, however. ☐	Teacher does not provide resources to relevant scientific knowledge to help learners formulate alternative conclusions and/or explanations. Instead, the teacher identifies related scientific knowledge that could lead to such alternatives, or suggests possible connections to such alternatives. ☐	Teacher explicitly states specific connections to alternative conclusions and/or explanations, but does not provide resources. ☐	No evidence observed. ☐
Learners communicate and justify their proposed explanations.					
Learners communicate and justify their proposed conclusions and/or explanations.	Learners specify content and layout to be used to communicate and justify their conclusions and explanations. ☐	Teacher talks about how to improve communication, but does not suggest content or layout. ☐	Teacher provides possible content to include and/or layout that might be used. ☐	Teacher specifies content and/or layout to be used. ☐	No evidence observed. ☐

Appendix A.2: Teacher’s Information Sheet and Consent Form for Classroom Observation

Classroom observation information sheet

Dear participant

My name is Faris Alsaadi, and I am a PhD student at the University of York in the UK. Currently, I am carrying out a research project to investigate Saudi science teachers’ perceptions of inquiry-based learning. I will be visiting your classroom at least 2 times for the purpose of learning more about inquiry-based learning practice; if you are a female teacher, my female research associate will conduct the observations on my behalf. The purpose of the observation is not to critique the performance of the teacher or to observe students. I (or my associate) will be making written notes on observations about your practice in the classroom. Your participation is entirely voluntary, and it is up to you to decide whether or not to take part.

The written notes will be held and treated confidentially by the researcher. The data will be stored by code number. Any information that identifies you will be stored separately from the data. Your name and school will not be disclosed in any reports of this research and will not be associated with your responses in any way that will enable anyone to identify you or your school. Data will be stored in secure filing cabinets and/or on a password protected computer and will only be accessible to the researcher.

Anonymised data may be kept indefinitely and may be used for future analysis and shared for research or training purposes; participants will not be identifiable. If you do not want your data to be included in any information shared as a result of this research, please do not sign this consent form.

You have the right to withdraw from the research at any time during data collection and up to 4 weeks after the data is collected by contacting Faris Alsaadi (details below).

The data that I collect may be used in *anonymous* format in different ways (e.g., in presentations or online). Please indicate on the consent form with a ☑ if you are happy for this anonymised data to be used in the ways listed.

I hope that you will agree to take part in this study. If you have any questions about the study that you would like to ask before giving consent or after the data collection, please feel free to contact Faris Alsaadi by email (fa769@york.ac.uk), or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk.

Thank you for taking the time to read this information.

Yours sincerely

Faris Alsaadi

Classroom observation consent form

Please express your consent to take part in this research by ticking each box in the table below, then signing and dating the form. Thank you!

I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described above.	☐
I understand that the purpose of the research is to investigate Saudi science teachers' perception of inquiry-based learning.	☐
I understand that the data will be stored in a password protected file and only Faris Alsaadi will have access to any identifiable data.	☐
I understand that my identity will be protected by use of a code or pseudonym.	☐
I understand that my data will not be identifiable, and the data may be used ….	
• in publications that are mainly read by university academics	☐
• in presentations that are mainly attended by university academics	☐
• in publications that are mainly read by the public [or other relevant groups]	☐
• in presentations that are mainly attended by the public [or other relevant groups]	☐
• freely available online	☐
I understand that anonymised data may be kept indefinitely.	☐
I understand that anonymised data could be used for future analysis or other purposes [e.g., other research and teaching purposes].	☐
I understand that I can withdraw my data at any point during data collection and up to 4 weeks after the data is collected.	☐

Name: ____ Date: ____________________

Appendix B.1: Teacher's Information Sheet and Consent Form for the Interview

Interview information sheet

Dear participant

My name is Faris Alsaadi, and I am a PhD student at the University of York in the UK. Currently, I am carrying out a research project to investigate Saudi science teachers' perception of inquiry-based learning. I am asking you to take part in this study by answering some interview questions. The interview questions will focus on your perceptions and beliefs about inquiry-based learning. The interview will last around 15 to 25 minutes. Your participation is entirely voluntary, and it is up to you to decide whether or not to take part.

All identifiable information that you provide will be held and treated confidentially by the researcher. The data that you provide will be stored by code number. Any information that identifies you or your school will be stored separately from the data. Your name will not be disclosed in any reports of this research and will not be associated with your responses in any way that will enable anyone to identify you. Data will be stored in secure filing cabinets and/or on a password protected computer and will only be accessible to the researcher.

Anonymised data may be kept indefinitely and may be used for future analysis and shared for research or training purposes; participants will not be identifiable. If you do not want your data to be included in any information shared as a result of this research, please do not sign this consent form.

You have the right to stop the interview or withdraw from the research at any time during data collection and up to 4 weeks after the data is collected by contacting Faris Alsaadi (details below).

The interview will be audio recorded and a transcript will be produced. You will be given the opportunity to comment on a written record of your interview.

The data that I collect may be used in *anonymous* format in different ways (e.g., in presentations or online). Please indicate on the consent form with a ☑ if you are happy for this anonymised data to be used in the ways listed.

I hope that you will agree to take part in this study. If you have any questions about the study that you would like to ask before giving consent or after the data collection, please feel free to contact Faris Alsaadi by email (fa769@york.ac.uk), or the Chair of the Education Ethics Committee via email education-research-administrator@york.ac.uk.

Thank you for taking the time to read this information.

Yours sincerely

Faris Alsaadi

Interview consent form

Please express your consent to take part in this research by ticking each box in the table below, then signing and dating the form. Thank you!

I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described above. ☐

I understand that the purpose of the research is to investigate Saudi science teachers' perception of inquiry-based learning. ☐

I understand that the data will be stored in a password protected file and only Faris Alsaadi will have access to any identifiable data. ☐

I understand that my identity will be protected by use of a code or pseudonym. ☐

I understand that my data will not be identifiable, and the data may be used ….

- in publications that are mainly read by university academics ☐
- in presentations that are mainly attended by university academics ☐
- in publications that are mainly read by the public [or other relevant groups] ☐
- in presentations that are mainly attended by the public [or other relevant groups] ☐
- freely available online ☐

I understand that anonymised data may be kept indefinitely. ☐

I understand that anonymised data could be used for future analysis or other purposes [e.g., other research and teaching purposes]. ☐

I understand that I can withdraw my data at any point during data collection and up to 4 weeks after the data is collected. ☐

I understand that I will be given the opportunity to comment on a written record of my responses. ☐

Name: ____ Date: ____________________

Appendix B.2: Interview Protocol

Background information

- How long have you been teaching science?
- What is your qualification?
- Which grades do you teach?
- How do you plan your science instruction? Do you follow the teacher's guidebook or student's textbook?

Follow-up questions from the observations (when necessary), for example:

- What did you want students to learn (knowledge, skills, understanding)?
- How did you choose your strategies to achieve this?
- Specific e.g., what was happening when…..? Why did you do …..?
- Would you describe this lesson as IBL?

Teachers' understanding of IBL

- How do you define IBL?
- How did you develop these understandings about IBL? When and where did you learn about IBL?
- What type of teaching practices (activities) take place when using IBL? Could you give examples?
- In inquiry-based learning, what is the teacher doing? (What is your role as a teacher?)

- In inquiry-based learning, what are students doing? (What is students' role?)

Teachers' beliefs about IBL

IBL is defined as a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations" (NRC, 2000, p. 23).

- What you think about this definition of IBL?
- Do you think IBL, as in the definition above, is an effective way of teaching science? Why? In what way?
- Do you think IBL is important for teaching science? Why?
- Do you think IBL improves students' achievements? How? In what way?
- Do you think IBL suitable for your students?

Implementation of IBL in the classroom

- Do you use IBL, as in the definition above, in your teaching? If so, how often? How do you do it?

Challenges of IBL implementation

- From your experience, could you tell me what obstacles you face when implementing IBL?
- What are your needs to implement IBL in this school?

Have you had any professional training regarding IBL? If yes, tell me about it? Was it useful?

If no, do you think you should have some training? What would you like?

Appendix C.1: Teacher’s Information Sheet and Consent Form for Online Questionnaire

Online questionnaire information sheet

Dear participant

My name is Faris Alsaadi, and I am a PhD student at the University of York in the UK. Currently, I am carrying out a research project to investigate Saudi science teachers’ perception of inquiry-based learning. I am asking you to take part in this study by answering the following questionnaire. The questionnaire includes demographic information, closed-ended questions, and open-ended questions. It will take 15 to 25 minutes to complete. Your participation is entirely voluntary, and it is up to you to decide whether or not to take part.

All identifiable information that you provide will be held and treated confidentially by the researcher. All of the data collected for this study will be anonymous when it is reported – no participants or schools will be identifiable. No personal or identifying data will be collected. The data will be stored in a password-protected file and will only be accessible to the researcher.

Anonymised data may be kept indefinitely and may be used in presentations, online, in research reports, in project summaries or similar. In addition, the anonymous data may be used for further analysis. Your individual data will not be identifiable but if you do not want the data to be used in this way, please do not complete the questionnaire.

You are free to withdraw from the study at any time during completing the questionnaire, simply by closing your browser. You can also choose not to answer any particular questions. Once the questionnaire is submitted the data it will not be possible to withdraw your data.

I hope that you will agree to take part in this study. If you have any questions about the study that you would like to ask before giving consent or after the data collection, please feel free to contact Faris Alsaadi by email (fa769@york.ac.uk), or the Chair of the Education Ethics Committee via email education-research-administrator@york.ac.uk.

By proceeding and submitting this questionnaire, you are agreeing to all of the points above.

Thank you for taking the time to read this information.

Yours sincerely
Faris Alsaadi

Online questionnaire consent form

Please express your consent to take part in this research by checking each box below. Thank you!

I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described. ☐

I understand that the purpose of the research is to investigate Saudi science teachers' perception of inquiry-based learning. ☐

I understand that the data will be stored in a password protected file and only Faris Alsaadi will have access to any identifiable data. ☐

I understand that my identity will be protected by use of a code or pseudonym. ☐

I understand that my data will not be identifiable, and the data may be used in publications and presentations for university academics or wider audience, or may be freely available online. ☐

I understand that anonymised data may be kept indefinitely and could be used for future analysis or other purposes [e.g., other research and teaching purposes]. ☐

I understand that I can decline to answer any particular questions, and I can withdraw my data at any point during data collection simply by closing my browser window. ☐

By clicking "proceed" below, you will confirm your consent and be redirected to the first page of the questionnaire. Thank you!

proceed

Appendix C.2: Online Questionnaire

First Part

About you as a teacher

1- What is your gender?
○ Male ○ Female

2- What is your highest level of qualification?
○ Diploma ○ Bachelors ○ Masters ○ Doctorate ○ Other…….

3- What is your teaching specialisation?
○ Physics ○ Chemistry ○ Biology ○ Geology ○ General science ○ Other ……

4- How long have you been teaching science?
○ 0-1 ○ 2-5 years ○ 6-10 years ○ 11-15 years ○ 16-20 years ○ over 20 years

5- Which levels you are teaching?
○ Primary ○ Middle ○ High

6- In which region of Saudi Arabia do you teach?
○ Riyadh ○ Makkah ○ Madinah ○ Qassim ○ Eastern region ○ Asir ○ Tabuk ○ Hail ○ The Northern Border ○ Jazan ○ Najran ○ Al Baha ○ Al Jouf ○ Other ……

7 - Have you had any professional training on inquiry-based learning?
○ Yes ○ No

Second Part

Teachers' understandings of inquiry-based learning

1- From your perspective, how do you define IBL in teaching science?
………
………

2- To what extent do you agree with the following statements about your views of inquiry-based learning in teaching science.

Does inquiry-based learning involve the following activities?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Students ask questions					
Students formulate hypotheses					
Students plan and carry out investigations					
Students use tools to gather, analyze, and interpret data					
Engaging students in problem solving activities					
Students listen to the teachers lecture and receive information from them					
Students formulate explanations from evidence					
Students communicate and justify explanations					
Students research what is known					
Students propose answers					
Students engaging in activities with predetermined outcomes					

Please use the space below to add any other activities of IBL not mentioned in the list.

…….

Third Part

Teachers' implementation of inquiry-based learning

IBL is defined as "a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations" (NRC, 2000, p. 23).

Note: from this point onwards, IBL refers to the above definition.

How often do you use inquiry-based learning in your teaching?	Never	Seldom (few times a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Always (almost all lessons)

If you implement inquiry-based learning in your teaching, can you explain how do you do it?

…….

Fourth Part
Teachers' beliefs about IBL

To what extent do you agree with the following statements	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
IBL is important for teaching science					
Teaching by inquiry helps students to understand of scientific concepts					
Teaching by inquiry develops students' abilities and skills					
Teaching by inquiry develops problem-solving skills					
Teaching by inquiry develops critical thinking skills					
IBL helps students to formulate their own knowledge					
IBL encourages students to discover, formulate questions and hypotheses					
IBL activities enhance and expand the learning process					
IBL makes students actively participate in the learning process					
IBL gives priority to students to learn and practice the processes of science					
IBL links science to students' lives and experiences					

Fifth Part

Teachers' perceptions about challenges of using IBL

From your perspective, to what extent the following challenges prevented you from implementing IBL in teaching science?

Statement	Not a Challenge	Slight challenge	Moderate Challenge	Large challenge	Major challenge
Lack of students' motivation					
Lack of students' abilities					
My insufficient content knowledge					
My insufficient pedagogical knowledge					
Classroom management issues					
The class period is insufficient to apply IBL					
It requires too much preparation time					
The large number of students in the class					
The assessment of students' learning					
Lack of resources					
The school system does not encourage changes					
Lack of teachers' professional development					
The curriculum contains a large amount of content that needs to be covered					

If there are other constraints to implementing inquiry-based learning that are not mentioned in the list, please add it in the box below.

………

Appendix D: Permission Letter to Conduct the Research from the Ministry of Education in Saudi Arabia

المملكة العربية السعودية

وزارة التعليم

الإدارة العامة للتعليم بمنطقة مكة المكرمة

إدارة التخطيط والتطوير

وزارة التعليم

Ministry of Education

الرقم :

التاريخ :

المشفوعات (المرفقات) :

الموضوع / الموافقة على تطبيق بحث فارس السعدي

تعميم لجميع المدارس لجميع المراحل (بين / بنات)

المكرم(ـة) قائد(ة) مدرسة/ وفقه(ـا) الله

السلام عليكم ورحمة الله وبركاته ...وبعد :

فيقوم الطالب / فارس عبدالله حامد السعدي والمبتعث إلى جامعة يورك بالمملكة المتحدة بإجراء بحث لنيل درجة الدكتوراه بعنوان:

((مفهوم التعليم القائم على الاستقصاء من وجهة نظر معلمي و معلمات العلوم في السعودية))

وحيث إن البحث يتطلب :

١ /تعبئة استبانة الكترونية من قبل معلمي/ معلمات العلوم بمدينة مكة المكرمة و ذلك من خلال الرابط التالي : http://cutt.us/bbc1440

٢/ إجراء مقابلة و ملاحظة مع معلمي/ معلمات العلوم و تسجيل بياناتها .

عليه آمل بعد الاطلاع التكرم تمكين الباحث من إجراء البحث وأدواته و ما يتطلبه داخل مدرستكم ، وحث الزملاء/الزميلات على التعاون معه (أو من ينوب عنه) شاكرين لكم كريم تعاونكم خدمةً للبحث العلمي، و تقبلوا تحياتي وتقديري .

٥/١

١٤٤٠هـ

مدير إدارة التخطيط والتطوير

أحمد بن فيصل الغامدي

كع ع. الدوسري الزهراني

Appendix E: Headteacher's Information Sheet (Consent Form)

Headteacher's information sheet (consent form)

Dear Headteacher of …………….school

My name is Faris Alsaadi, and I am a PhD student at the University of York in the UK. Currently, I am carrying out a research project to investigate Saudi science teachers' perceptions about inquiry-based learning. I will be visiting science classroom lessons twice for the purpose of learning more about inquiry-based learning practice. The purpose of the observation is not to critique the performance of the teacher or to observe students. I will be making written notes on my observations about teachers' practice in the classroom. The teachers I observe will have given me their individual informed consent to take part in my study in this way.

The data may be used for future analysis and shared for research or training purposes, but neither participants nor the school will be named or identifiable.

I hope that you will agree to give me a permission to collect data by observing science teachers at your school. If you have any questions about the study that you would like to ask before giving consent or after the data collection, please feel free to contact Faris Alsaadi by email (fa769@york.ac.uk), or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk. You may withdraw your school from my study by contacting me at any point until my data collection is complete.

Thank you for taking the time to read this information.

Yours sincerely

Faris Alsaadi

I confirm that I have read and understood the information given to me about the above-named research project and I give permission to Faris Alsaadi to undertake his study in the school.

Signature…………………….. Date……………………

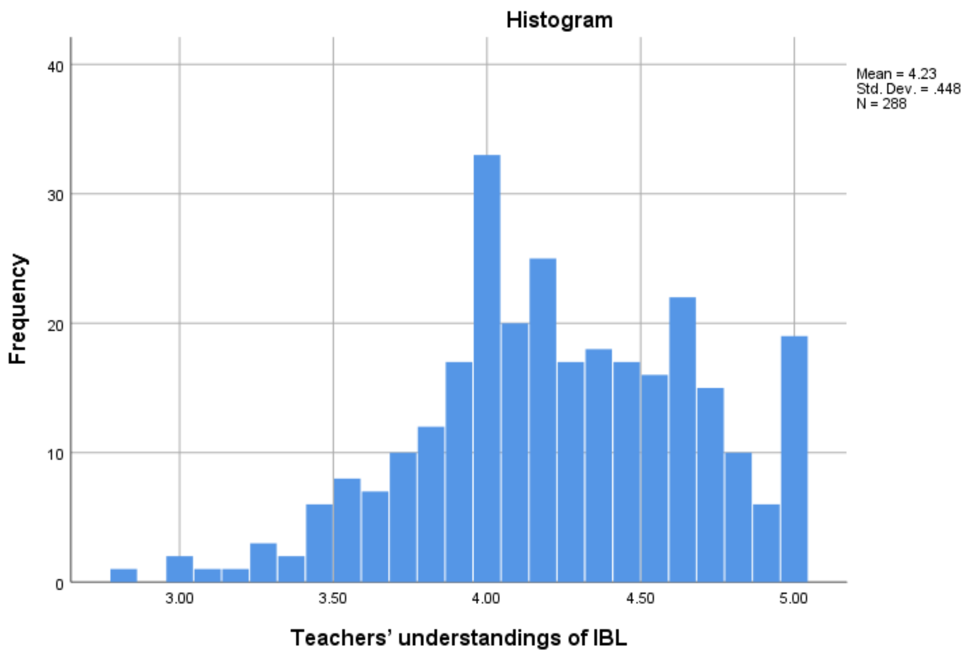
Appendix F: Normality Tests

Tests of Normality

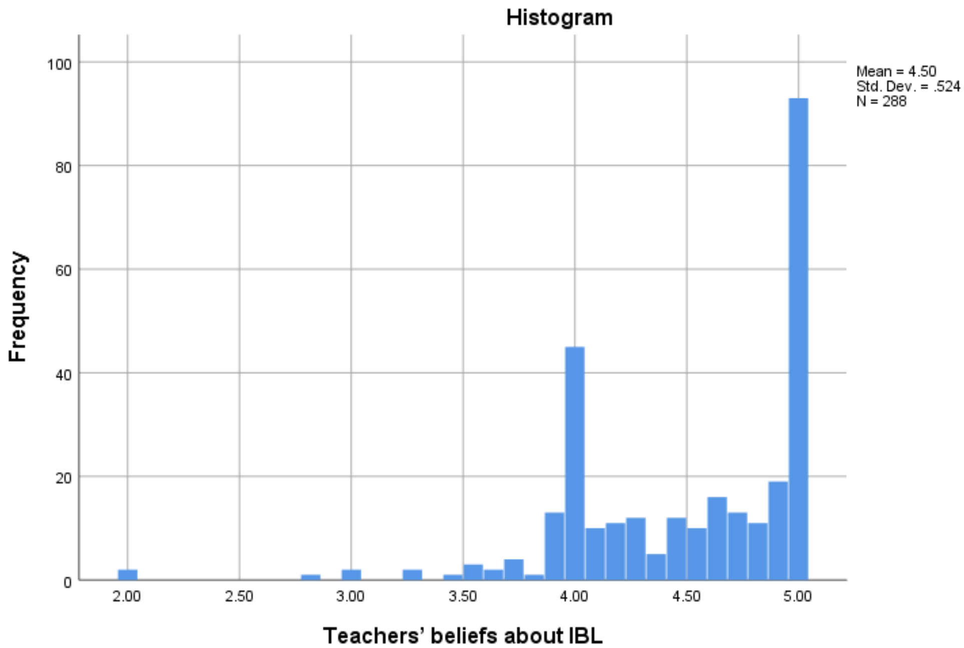
Scale	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Teachers' understandings of IBL	.066	288	.004	.979	288	.000
Teachers' beliefs about IBL	.171	288	.000	.839	288	.000
Teacher' perceptions about the obstacles to using IBL	.075	288	.000	.981	288	.001

a. Lilliefors Significance Correction

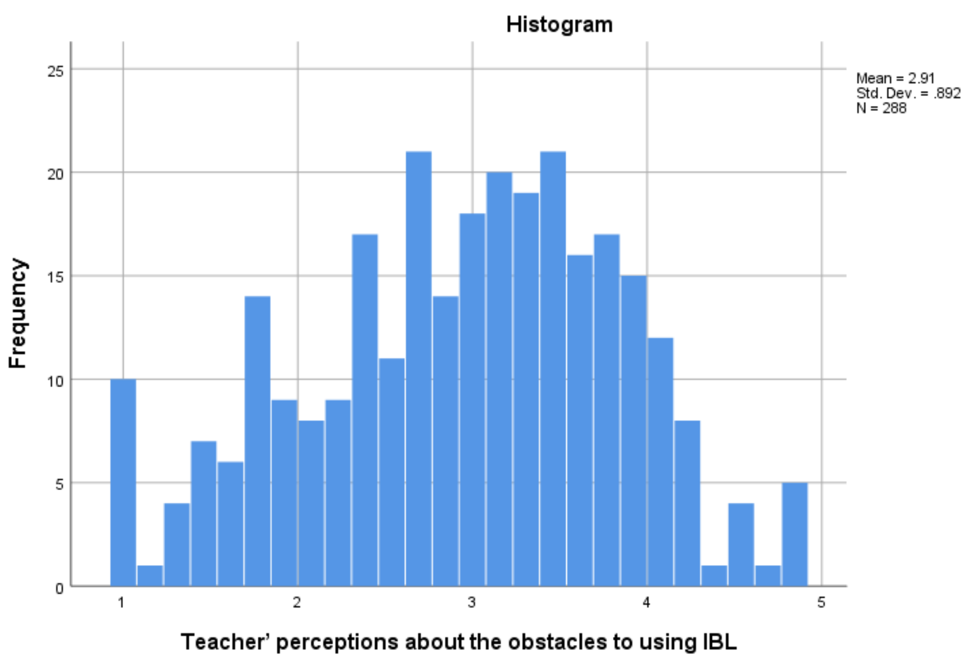
Histogram 1. Data distribution for the scale 1 (teachers' understandings of IBL)



Histogram 2. Data distribution for the scale 2 (teachers' beliefs about IBL)



Histogram 3. Data distribution for the scale 3 (teacher' perceptions about the obstacles to using IBL)



Appendix G: The Results of Chi-square Test About the Relation Between Level of Teachers' Knowledge of IBL and Different Variables

Classification of teachers' knowledge of IBL	Gender		Teachers' school levels		Teaching experience		Teachers' specialisation	
	Chi-square statistic value	p-value	Chi-square statistic value	p-value	Chi-square statistic value	p-value	Chi-square statistic value	p-value
No Knowledge	1.986	0.158	0.650	0.722	2.382	0.665	26.656	*0.000
Uncertain Knowledge	0.476	0.489	1.599	0.449	7.487	0.112	3.181	0.527
Basic Knowledge	0.0715	0.789	3.063	0.216	1.787	0.774	2.960	0.564
Fair Knowledge	2.857	0.090	8.946	*0.011	4.298	0.367	3.143	0.534
Good Knowledge	0.161	0.687	0.825	0.661	4.138	0.387	0.521	0.914

*The result is significant at $p < .05$.

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