Effects of Science Inquiry-based Professional Development (IBPD) on Teachers' Attitudes, Knowledge, and Practices in UAE

لمادة العلوم على سلوك ومعرفة واداء المدرسين في الأمارات أثر التطوير المهني في المنهج القائم على التحقيق

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ID number 2014101062

Dissertation submitted in partial fulfilment of the requirements for the degree of MED in Management and Leadership

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March 2016

DISSERTATION RELEASE FORM

Student Name	Student ID	Programme	Date
Rania Suleiman Amaireh	101062	MED –Leadership and Management	March 25, 2015

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Abstract

Scholars and education reformers alike have reignited the importance of teaching science using the inquiry-based learning approach. However, the lack of knowledge and skills about this approach in addition to teachers' practices of traditional approaches are reasons for not applying the IBL in practice during science lessons in UAE. Therefore the need for an inquiry-focused professional development program is crucial to prepare science teachers and to enrich their knowledge about IBL. Moreover, it will change their perceptions, attitudes and beliefs about the proper method used to teach science. This study examines the impact of five days of professional development (PD) on science teachers when teaching science using the inquiry-based learning approach (IBL). The five days of PD provides a comprehensive experience of inquiry-based science concepts and pedagogy. Thirty-nine science teachers from different phases (K to 12) participated in this study in one of the private schools in Dubai that follows the American curriculum. All participants attended the five days of PD and responded to 41 items in pre- and post-PD surveys addressing teachers' perceptions of their confidence levels and their concerns and interests in implementing the IBL approach, in addition to their knowledge and practices in class. Several class observations and in-depth interviews were conducted to provide more accurate indications of teachers' attitudes and practices.

The major results of the study indicate that teachers' attitudes, knowledge, and practices of IBL have improved after attending the inquiry-based learning professional development (IBPD) program. Interestingly, the study found that teachers from scientific backgrounds were more affected by the IBPD as they practice more inquiry when teaching science than their peers from non-scientific background; however, KG and elementary teachers have shown more positive attitudes towards IBL after the PD sessions than middle and high school teachers. The study revealed some challenges when implementing the IBL approach in science lessons, such as: limited resources, lack of time, teaching the students with academic difficulties, special needs, and language disability of ESL students.

Keywords: professional development, inquiry-based learning, teachers' attitudes, teaching practices, teachers' knowledge, challenges of IBL.

الملخص

المؤسسات التعليمة و الأكاديميةعلى حد سواء تؤكد على أهمية استخدام منهج التعليم القائم علي التحقيق (IBL) عند تدريس مادة العلوم ولكن النقص في معرفة و ممارسة هذا المنهج بالاضافة الى التصورات التقليدية السائدة عند المعلمين تشكل عائقا لتطبيقه في حصص العلوم في دولة الأمارات. ولهذا السبب تعد الحاجة ملحة الى برامج التطوير المهني المعنية بالتعليم القائم على التحقيق لتأكيد جاهزية معلمي مادة العلوم و لأثراء معرفتهم بهذا المنهج بالأضافة الى تغيير تصوراتهم و سلوكهم و معتقداتهم و ممارساتهم حول استخدام المنهج الأمثل لتدريس هذه المادة .هذه الدراسة تقييم أثر برنامج التطوير المهني الذي مدته خمسة أيام على مدرسي مادة العلوم عند تدريسهم باستخدام منهج التعليم القائم علي التحقيق .(IBL) هذه المدة تقدم تجربة شاملة لمفا هيم و نهج التعليم المتبع .شارك في هذه الدراسة 39 معلم علوم من مختلف المراحل الدراسية (الروضة- الصف الثاني عشر) في احدى المدارس الخاصة في امارة دبي والتي تتبع المنهاج التعليمي الأمريكي. جميع المشاركين في البرنامج التطويري أجابو على استبيان شمل 41جانب قبل و بعد المشاركة بالبرنامج .من الجوانب التي شملها الاستبيان تصورات المعلمين حول مدى ثقتهم و تخوفهم و اهتمامهم بتطبيق النهج القائم على التحقيق بالاضافة الى معرفتهم و ممارساتهم لهذا المنهج في الصف. تم استخدام العديد من البيانات التي جمعت من خلال الزيارات الصفية و اللقاءات التي اتخذت الطابع العميق لتزويد الدراسة بدلائل أكثر دقة عن سلوك و ممارسات المعلمين.

النتائج الرئيسية للدراسة تدل على أن سلوك و معرفة و ممارسات المعلمين لمنهج التعليم القائم على التحقيق قد تحسن بعد مشاركتهم في برنامج التطوير المهني المعني بهذا المنهج. ومن النتائج المثيره للاهتمام أن المعلمين الذين لديهم خلفية دراسية علمية كانو أكثر تأثرا ببرنامج التطوير المهني حيث أنهم يمارسون هذا المنهج عند تدريس مادة العلوم أكثر من نظرائهم الذين ليس لديهم هذه الخلفية. كما أظهرت النتائج أن معلمي الروضة و الأبتدائي أظهرو سلوكا ايجابيا حول منهج التعليم القائم على التحقيق بعد المشاركة في البرنامج التطويري أكثر من معلمي المراحل المتوسطة و الاعدادية.كما أظهرت الدراسة بعض التحديات التي يواجهها المعلمين عند تطبيق هذا المنهج مثل المصادر المحدودة و الوقت المحدود و تفاوت قدرات الطلاب الأكاديميةو التعليمية الناتجة عن احتياجات خاصة و لغوية لغير الناطقين باللغة الانجليزية.

الكلمات والعبارات الرئيسية:

برامج التطوير المهني- التعلم القائم علي التحقيق - سلوك المعلمين- ممارسات المعلمين- معرفة المعلمين- التحديات لمنهاج التعلم القائم علي التحقيق

Acknowledgments

The completion of this dissertation would not have been possible without the support of my great mentor Dr. Sufian Forawi who believed in me and inspired me to achieve and succeed. I dedicate this work to my two little heroes, Kerim and Ryan, for being around and giving me the courage with their energy and love. I take this opportunity to apologize to them for being away busy studying for the past two years and missing a lot of fun times that we could have spent together.

A special thanks to my rock, my mother, who has always been a role model to me with her persistence and strength.

I would like to extend my thanks to my professors who accommodated me at their classes and guided me over the last two years.

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Chapter 1: Introduction

Teachers' education is one of the important features of schools and education systems. It is the main reason to promote improvements and transformations claimed by changing societies (Day 2001, cited in Lino 2014). Chapman and Aspin (2001, cited in Lino 2014), highlight the need of transforming the present education system in order to face the challenges of knowledge and information of societies. They claim that gaining a number of skills and learning new abilities are necessary to meet the new demands of societies, and these are crucial to have a permanent learning that is continuously carried out to improve practices, knowledge and perspectives. The rapid changes in economy and society resulted in innovational changes in all systems including the educational system. Therefore, schools' and teachers' roles and responsibilities have also changed as standards and demands rise to maintain the excellence of the students' attainment (Iftani & Fotopoulou 2011). School leaders are under a growing pressure to provide a high quality of education (Clement & Vandenberghe 2003). Teachers play the most crucial role in the excellence or failure of the school system, and qualified teachers are the reason of raising a generation that is ready to face the global problems. Recently, this role has witnessed a paradigm shift (Hartsell et al. 2009). Moreover, teachers need to reform their professional practices and improve their education (Boudah et al. 2001). Supporting this claim, Ozdemir (2013) states that a teacher who cannot continuously develop and progress ends up outdated. He adds that training teachers will empower them to maintain their jobs and incomes.

Previous studies have focused on the impact of professional development (PD) on teaching and learning practices. The positive influence on pedagogy, curriculum, and student attainment through PD is discussed by many researchers (Gordon 2004; Talbert & Mclaughlin 1994; Talecvski et al. 2011). Lee & Shui (2008) claim that PD is a continuity of school development and the guarantee of the high quality of teaching and learning. Furthermore, the effective training creates positive and determined teachers who are active performers and a considerable factor in students' academic achievements (Makori & Onderi 2013).

1.1 The Research Problem

Schools need effective and well-prepared teachers for classroom practices through continuous professional development (CPD) programs (Lino 2014; Tartar & Buldur 2013; Vendlinski et al. 2009). Recently, the debate of the relationship between teachers' retention and students' attainment is a concern of most educators. Therefore, schools focus on hiring qualified teachers. This is especially due to many research studies that support the relationship between the teaching quality and the academic success of the students (Templeton & Tremont 2014). In order to improve students' attainment, teachers need to develop their knowledge and practices of new pedagogical techniques (Ainscow 2011; Tatar & Buldur 2013; Vendlinski et al. 2009).

Professional development is a term that can target every part of the educational organization for the purpose of providing better education and positively affecting the learning process. It targets teachers' perspectives, motivation, pedagogical knowledge and practices for improved classroom experiences. It also targets school leaders and other supporting staff. (Aubrey & Coombe 2010).

In science, there is a trend of inquiry-based learning and a claim of supporting teachers to develop their inquiry instructions (Forawi & Liang 2011). Science educators are directed to think of PD programs that enhance this skill and prepare teachers to implement it. Through inquiry learning, students will develop important skills that allow them to ask questions, plan investigations, collect data and use tools, analyze the data, and communicate the result (Friedl 2005).

Regardless of how often the science educational community and the national science education policy (NRC 1996 and NRC 2012) call on inquiry-based teaching, the progress in this domain is very slow. Science classrooms are still controlled by teacher-centred instructions as teachers' personal experiences, beliefs, and knowledge affect the instructional decisions in classes *(*Appleton & Kindt, 2002; Blank 2012; Kazempour & Amirshokoohi 2013). However, the recent science approach that encourages engaging students in real life experience and authentic science learning is the key to science literacy (Hume 2009). The role of the instructor has shifted from lecturing to supporting the process of learning by providing an open-mind-discussion atmosphere, where students debate and think critically and provide evidences for their arguments. This approach will help the students to be self-directed researchers and lifelong learners (Abdal-Haqq 1998).

Moreover, research shows that providing teachers with Inquiry-based PD and involving them in such programs increases their concerns and interests regarding implementing it (Kapanadze et al. 2015).

Using the inquiry-based approach in teaching science requires familiarizing teachers with the nature of the scientific inquiry and the inquiry-based learning practices. This issue led the science reform documents to start inquiry-based PD as a main tool to facilitate the acceptance and implementation of inquiry-based learning. Studies have mainly focused on two critical features. The first one is providing a long-term research-based PD experience that provides collaborative opportunities for teachers to work with their peers, and the second feature is to enhance the teachers' content knowledge (Kazempour & Amirshokoohi 2014).

The United Arab of Emirates (UAE) has experienced a significant shift since 2007 across teaching different subjects, including science. Prior to the mentioned year, thousands of hours of teaching were conducted by inadequately trained teachers who do not hold professional teaching qualifications (Dikson & Kadbey 2014). Historically, science has been taught using old and traditional teacher-centered approaches such as chalk and board and lecturing. Preservice teachers hold beliefs about teaching science based on their old schooling experiences and they carry these negative beliefs to their classes (Dikson & Kadbey 2014).

In addition to the traditional old fashioned teaching, teachers' interfering and intensive support to students are reasons for not implementing the inquiry-based learning properly in UAE, as indicated by Tairab (2010) and Al Naqabi (2010). Moreover, socio-cultural issues impact shaping science education in the Arab world generally and UAE in specific. Issues such as religions, values, and traditions are all dynamics that can be part of shaping science learning in the Arab countries. The fact that we can learn about nature only through conceptual epistemological framework delays the education development in general and science inquiry approach in particular (Mansour & Al-Shamrani 2015). Limited background or skills and materials shortages are other faced challenges mentioned by Naqabi (2010).

Nowadays, the government represented by Abu Dhabi Educational Council (ADEC) is encouraging the modern teaching approaches such as the IBL in science (Dikson & Kadbey 2014).The rapid educational reform movement and the force of educational authorities toward inspecting and evaluating the schools based on students' progress and attainment has imposed the schools to provide sufficient PD programs to their staff (Ibrahim & Al Taniji 2012; Mansour & Al Shamrani 2015). For instance, TESOL Arabia is an organization that provides the PD service in the Middle East (Aubrey & Coombe 2010). Furthermore, inspection councils and authorities such as Abu Dhabi Education Council (ADEC) in Abu Dhabi, and Knowledge and Human Development Authority (KHDA) in Dubai are providing PD programs for educators and school leaders. ADEC has launched a program called "Empowering Teachers" that develops a comprehensive action plan offering training programs to achieve professional standards and provide students with the best pedagogies (ADEC 2015; KHDA 2015).

1.2 Significance of the Study

PD is an important area of research at many different levels. Some research focuses on content, and duration of PD, others on the impact of the content on teaching. These continuous research studies on teachers' PD will help to create a knowledge base that links PD to effective teacher learning (Fishman et al. 2003). Recently, the development of teachers and providing them with opportunities to learn has become a central issue and interest of many educational organizations (Gunnarsdottir 2014).

As per science education research, a great impact on students' understanding and performance is shown when teaching students using the IBL approach (Forawi & Liang 2011). However, the practice of this approach has shown that implementing IBL and teachers' ability to utilize this process is a major challenge (DiBiase & McDonald 2015). This is also the case in UAE, which makes PD programs for teachers in this area crucial.

Investigating the impact of IBPD programs on teachers can help in enhancing their knowledge, perspectives, and practices and these changes can be linked to enhance students' achievements (Capps et al. 2012). It will lead teachers to use more student-centred and constructivist approaches in teaching (Kanselaar 2002, cited in Rooney 2012). Furthermore, it will help teachers to re-evaluate their teaching approaches in science and replace their old traditional methods with the IBL approach. Knowing the impact of the IBPD on teaching can drive schools' districts, policies, and decision maker to conduct science inquiry PD on a regular basis (Capps et al. 2012).

Despite an increased interest in developing science teachers' teaching skills and knowledge in inquiry-based learning, few studies have been published on this topic. A comprehensive search of the literature revealed that for the most part, only general reviews have been published on science teacher PD, such as Hewson (2007) and Kennedy (1998) and no targeted review of PD programs focused specifically on scientific inquiry (Capps et al. 2012).

In countries such as UAE and in a multinational city such as Dubai, the high teacher turnover every year is a great challenge for many schools. Schools are under the pressure of maintaining best practices and records based on annual inspection visits of the KHDA regardless of the high turnover. Therefore, PD is one of the main strategies schools use to accommodate the KHDA recommendations and accomplish the improvement plans.

Limited studies have been conducted on the same topic in UAE, a country which is rapidly developing its educational system (Dikson & Kadbey 2014). Many researches have studied the IBL from students' perspective (Hanauer & Bauerle 2012; Harrison 2014; Nowak et al. 2013), however, less researches have studied the impact of using this approach on teachers. Therefore, this research will be of interest nationally and internationally to other countries experiencing educational improvement in science and trying to train science teachers to teach using an approach which may be completely different than what they have experienced as students.

This study is aiming to evaluate the impact of the delivered PD content practices, which is related to IBL, on the quality of teachers' practices, attitudes, and knowledge in a private school in Dubai. Sabah et al. (2014) insists that organizing PD programs is insignificant unless it is followed by successful implementation efforts and clear evidence of its effectiveness. The provided IBPD is framed within existing school culture, inquiry-based, and collaborative sessions to ensure the effectiveness (Darling Hammond et al. 2009, cited in McNicholl 2013). Moreover, PD programs should provide teachers with opportunities to be engaged in authentic inquiry-based practices within the sessions. Modeling the strategies and providing practical sessions where teachers can personally experience the IBL scenarios and see the entire process will make applying them more effective (Capps et al 2012; Kazempour & Amirshkoohi 2014).

1.3 The Purpose and Questions of the Study

The main purpose of this study is to investigate the effects of inquiry-based professional development (IBPD) on science teachers’ attitudes, knowledge and practices in UAE. A mixed-method approach is used to investigate the private K to 12 science teachers’ attitudes, knowledge, and practices of implementing the IBL after attending the IBPD sessions in Dubai. The study examined the scope of the positive relationship between an inquiry-based PD program and of both teaching quality in terms of knowledge and practice and teachers’ attitudes in terms of concerns and interests. Other factors and their effect on implementing and practicing the IBPD are investigated such as the teaching phase, major in university, years of experience, and the taught core subject.

To enhance the confidence in the ensuing findings, triangulation design of the mixed methods has included the qualitative approach of semi structured interviews and observational study along with the quantitative methods such as pre- and post-PD questionnaires.

To obtain a clear picture about the inquiry based-learning situation in UAE, this study intends to investigate the following questions:

- What is the effect of the IBPD program on teachers’ attitudes?
- What is the effect of the IBPD program on teachers’ knowledge?
- What is the effect of the IBPD program on teachers’ practices?
- What are the main challenges of implementing the IBL in science lessons?

1.4 Context of the Study

The context for this study is the PD of science teachers who teach in one of the private schools in UAE. Teachers of different grade levels (K-12) attended an IBL focused collaborative sessions. The PD included all grade level teachers to investigate other demographical factors on the effectiveness of the PD program. Thirty-nine teachers were selected to participate in a survey, pre and post the PD sessions, to obtain the changes in their attitudes, perceptions of knowledge and practices after attending the PD. Selected teachers were observed and interviewed to elaborate on their utilization of the IBL approach in their science lessons.

1.5 Structure of Dissertation

This study includes five main chapters. This chapter, the introduction, has provided a brief overview of the research problem and important definitions worldwide and in UAE. It also provides the significance, other research deficiency, context of the study, purpose of the study, and the main questions investigated. The second chapter is the theoretical framework and literature review which explains what has been said and found about IBPD programs and their effect on teachers' attitudes, knowledge, and practices. The third chapter outlines the methodology used including the two qualitative and quantitative approaches used to collect the data. Furthermore, instruments, sampling, reliability, validity, and ethical consideration. Data and results are analyzed in chapter four. Finally, chapter five presents the conclusion, discussion of findings, and recommendations.

Chapter 2: Theoretical Framework and Literature Review

This chapter of the study presents a review of different literature related to IBPD implementation in science classes. Particular attention is paid to the historical and theoretical research backgrounds that highlight the importance of IBPD programs followed by more focus on teachers' different attitudes, knowledge, and practices of the IBL approach and how the IBPD programs can affect them. The literature provides evidences for the effective IBPD on teachers' attitudes, knowledge, and practices. Finally, main challenges, discussed in different reviews, are presented.

2.1 Inquiry-based Professional Development (IBPD) Programs

The term "professional development" refers to the improvement and growth that happens to a person during his or her professional cycle (Crowther 2000, cited in Lino 2014). In order to advance and develop in their careers, teachers should seek out PD opportunities (El Deghaidy et al 2015; Lino 2014; Tatar & Buldur 2013). These include formal processes, such as conferences, workshops, seminars, and other sessions that reinforce the collaborative learning, and informal processes, such as colleagues' discussions, peers observations, or self-reading (Brill 2015). All these processes are important due to the need of being well equipped with teaching competencies that need to be restructured according to the pedagogical needs in classes. This will reflect the continuous contemporary and advancement in subjects and skills (Donaldson 2011, cited in El Deghaidy et al. 2015).

Recent years have seen a growing call for inquiry in teaching science as it provides a valuable experience to improve students' understanding of both science content and practices. Inquiry-based learning is known as the "innovative approach" and it is based on the recognition that science is essentially a question-driven and open-ended experience where students have personal experience with scientific inquiry to understand the fundamental aspects of science (Edelson et al. 2007). Over a decade ago in the United States, the educational consultants and documents suggested shifting science teaching to have less emphasis on direct instruction to more emphasis on inquiry-based instruction (Capps et al. 2012). However, many teachers are unable to employ and adopt the inquiry-based approach in their instructional practices as it is an abstract idea that lacks the authentic experience both in their own old educational systems and their teacher preparation programs to becoming teachers (Kazempour & Amirshokoohi 2014). Many teachers have confusion in defining the word inquiry as this word has been stretched and twisted by different academic disciplines. Teachers who did not personally experience engaging the scientific inquiry in their classes may relate inquiry to other similar techniques such as hands-on activities, learning by doing, and problem based learning (Capps et al. 2012), however, according to the National Science Educational Standards (NSES), doing inquiry includes asking questions, planning and designing an experiment, collecting data, and providing explanations (Capps et al. 2012). Recently, the Next Generation Science Standards (NGSS), the recently adopted standards in the US, emphasize the importance of using the inquiry approach as part of the engineering practices' dimension (NRC 2012).

Inquiry-based Learning is a constructivist approach which focuses on constructing the knowledge of the active student rather than drilling and memorizing facts. It is a student-centred learning where the role of the teacher is limited to guiding students through an active search for knowledge (Capps et al. 2012; Cobern 2010). Students can experience how scientists have produced new knowledge and what they feel when they get it (Cobern 2010). The constructivism in science learning requires the engagement of students in answering authentic questions related to their lives and constructing their own learning of complex information through transferring the knowledge (Brown et al. 1989; Slavin 2015).

Since this approach requires teachers familiar with both the nature of the inquiry and how to implement it in the class (Kazempour & Amirshokoohi 2014), many studies have called for the importance of professionally developing science teachers through collaborative and active engagement with peers in order to improve their pedagogical knowledge and practices. It is found that focusing on PD in science education has stressed the impact of PD on teachers' attitudes, knowledge, and teaching practices (Capps et al. 2012; Kazempour 2009; Kazempour& Amirshkoohi 2014; Lotter et al. 2006).

According to Capps et al. (2012, p. 296), Inquiry-based Professional Development (IBPD) is "one that consists of activities that support teachers in creating classroom environments in which students learn science concepts and principles through inquiry, as well as learn about what science is, and how scientists work".

The main characteristic of the effective IBPD is in allowing teachers to be engaged in authentic inquiry-based practices, model the strategy, connect the PD sessions to classwork, improve the content knowledge, reflect on what they know, and allow enough time to practice the PD activities (Capps et al. 2012). Modeling the strategy is very significant as one of the effective PD programs' features and this can be implemented when teachers personally experience a complete inquiry-based scenario and witness the entire process as students would in a real classroom (Kazempour & Amirshkoohi 2014).

Allowing teachers enough time to fully address their misconceptions and doubts regarding the IBL is crucial, therefore, programs that run for a week or more focusing on the same concept are more acceptable (Capps et al. 2012).

2.2 Teachers' Attitudes towards IBL

Teachers' attitudes towards the IBL can be assessed through their beliefs, self-efficacy, and confidence (Gunduz 2014; Kazempour 2013).

Teacher's beliefs refer to the part of existing knowledge that monitors actions. This existing knowledge is psychologically constructed to form conceptions that are felt to be true; however, they might not be (Dolphin & Tilloston 2013). Ornstein (1986) believes that one of the main issues of educational practices is the idea that teachers are handicapped by their own biased beliefs about the definition of good teaching (McMinn et al. 2015). For instance, teachers' beliefs and understanding of the IBL and epistemological practices are built on their pre-existing presumptions and personal experiences. Furthermore, their practices in class have been influenced by these beliefs (Kazempour 2013). In UAE, socio-cultural factors and old fashioned beliefs in the society lead to less inquiry in schools (Mansour & Al Shamrani 2015).

Teachers' attitude towards teaching science is also affected by their own K to 12 learning experiences when they were students in school, so their negative attitudes about the subject and teaching have been transferred to their own classes (Kazempour 2013). Fishbein & Ajzen (1975) describe attitude as a person's positive or negative evaluation of the object (Kazempour 2013).

The teacher's attitude can predict the teaching behaviour, and any change in this attitude will lead to change in the teaching behaviour (Carter 2007, cited in Dolphin & Tilloston 2013). In science, teachers' positive attitude about science has a crucial role in affecting students' attainments and attitudes towards the subject (Kazempour 2013). However, science is still taught through teacher-centred approaches that rely on lecturing, worksheets, textbook-based assignments, and reading texts about science. The increasing of traditional activities and fewer hands-on or laboratory activities is an obvious trend especially in the elementary phases. Elementary teachers avoid teaching science due to negative attitudes toward science as well as their low level of confidence in teaching science (Kazempour 2013). Moreover, the traditional belief that K to 4 learners are too young to learn and function using experimentation is another reason to implement less inquiry in the elementary phase (Bybee 1993, cited in Furtado 2010). However, educators start to accept the evidence-based studies which approve that exposing young learners to the IBL process and engaging them in experimenting during science lessons help them to navigate through the science process and be comfortable at advanced stages (Furtado 2010).

In order to face these negative beliefs and lack of confidence in teaching science, enrolling teachers in PD programs is essential. Research show significant changes in responses to the importance of IBL and the level of confidence in implementing it after PD programs (Kazempour 2013; Tairab 2010; Tatar & Buldur 2013), however, these changes are more obvious in new teachers than expert teachers (Kazempour 2013).

Another factor that can affect the proficiency of teaching is the self-efficacy of the teacher. According to Bandura's social cognitive theory, the person's behaviour is affected by his or her cognitive process, and the existing knowledge and beliefs build the expectations that play a vital role in determining the future (Tatar & Buldur 2013). Bandura (1986, P.391) defines self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances". It is explained later that efficacy does not judge the ability or the skill, but what a person can do with these abilities and skills (Bong & Skaalvik 2003, cited in Skaalvik & Skaalvik 2013). Research shows that people with high metacognition, who are usually able to predict their success and are confident of achieving their goals, have more self-efficacy, and more will to succeed (Gunduz 2014). Science teaching self-efficacy refers to a teacher's ability to teach science effectively and the confidence that the teacher's students are learning science (Kazempour 2013). Teachers' efficacy can be improved by enrolling them in PD programs to improve their pedagogical knowledge, as many teachers are demotivated to try new ideas and techniques due to lack of knowledge of the new pedagogical concepts and tools (Tatar & Buldur 2013). Moreover, allowing teachers to observe their experienced peers can also play a vital role in changing their attitudes and raising their confidence (Duran et al. 2009). Furthermore, collaboration and cooperation during PDs enhance teachers learning and help them to articulate a rationale for their decisions (Lyngved et al. 2012).

In their study about improving teachers' self-efficacy through PDs, Tatar & Buldur (2013) claim that, social collaborative interaction and experiencing the new pedagogical practices through PD can positively affect teachers' self-efficacy and confidence in addition to increasing their positive feelings and decreasing their fears about trying the new practices. Providing teachers with IBPD alters their concerns and confidence, reduces perceived doubts, provides enough information to ease the implementation, and drops the anxiety level of adopting the IBL in classroom (Furtado 2010).

2.3 Teachers' Perceptions of IBL Knowledge and Practices

For teachers to grow in their education career, various knowledge is required to be constructed: content knowledge, pedagogical content knowledge, and practical knowledge (Ratinen et al. 2015). Content knowledge is represented by teachers' understanding of the subject matter taught. The pedagogical content knowledge is needed to make the subject matter accessible to students. Insufficient content knowledge of both will lead to inappropriate teaching practices (Shulamn 1987, cited in Ratinen et al. 2015). Moreover, teachers' practical knowledge that guides teachers in the classroom is affected by their goals, values, and principles of education (Lotter et al. 2007).

Research shows that many teachers lack the necessary competence in science subjects (Lyngved et al. 2012). The traditional style is more dominant when teaching science and only a small percentage of science teachers are using the IBL approach successfully (Lyngved et al. 2012). Most science teachers teach their students the way they have been taught themselves, which is delivering the content by means of lectures and assigning readings (Dikson & Kadbey 2014;

Gonzalez 2013; Naqabi 2010). Teachers use a deductive approach as they first instruct students with facts, concepts, and theoretical models followed by textbook exercises. Eventually, students get the opportunity to experience a real life problem and find a solution. However, a contemporary approach is generated through IBL which is provided through inductive learning; where the teacher first presents an inquiry or a complex real life problem to solve. While students observe and investigate the problem they realize the importance of facts and conceptual understanding (Prince & Felder 2007, cited in Furtado 2010).

A number of research have examined the impact of science teachers' content knowledge on how effectively they teach. They found that science teachers possess low levels of content and factual scientific knowledge as well as insufficient skills to teach using the IBL approach (Aditomo 2013; Calik & Ayas 2005; Capps et al. 2012; Tairab 2010). When comparing the high school science teachers' knowledge of IBL approach to elementary and KG science teachers', research show that elementary and KG teachers lack the exposure to and experience with IBL (Choi & Ramsey2009; Chung Lee 2011; Fortado 2010; Gonzales 2013; Ratinin et al 2015) This leads to have inadequate science education in this phase (Choi & Ramsey 2009). As a result of the poor knowledge, science teachers do not involve their students in various inquiry activities and strategies such as making predictions and designing investigations (Tairab 2012). This lack of content knowledge of an IBL approach as a major pedagogical practice in class can be solved by engaging science teachers in PD sessions that influence their knowledge and perceptions which will affect their decision-making process to favor of an IBL approach when teaching science (Choi & Ramsey 2009). Teachers need to develop their own understanding of this approach before guiding their students to apply it (Chung Lee 2011).

Teachers need to understand the structure of their discipline and have the skill to transfer the content knowledge into meaningful activities so they teach with confidence and positively impact students learning (Tairab 2012). Moreover, enriching teachers' knowledge about IBL and other new pedagogical approaches leads to major changes in their roles in the class, from being a "sage on the stage" to "a guide on the side" (Gonzalez 2013). Research also show that doing experiments alone does not lead to better outcomes for students. In order to support students' inquiry learning, teachers must be aware of the different phases and aspects of inquiry as it has different levels of openness (Banchi & Bell 2008). Table (1) shows the different levels and descriptions of inquiry that science teachers must know in order to practice them.

Level of Inquiry	Description
Structured	Strongly teacher-directed. Students follow their teacher's direction in pursuing a scientific investigation to produce some form of prescribed product, e.g. they investigate a question provided by the teacher through procedures that the teacher determines, and receive detailed step-by step instructions for each stage of their investigation.
Guided	More loosely scaffolded. Students take some responsibility for establishing the direction and methods of their inquiry. The teacher helps students to develop investigations, for example offering a pool of possible inquiry questions from which students select, and proposing guidelines on methods.
Open	Strongly student-directed. Students take the lead in establishing the inquiry question and methods, while benefiting from teacher support. For example, students initiate the inquiry process by generating scientific questions and take their own decisions about the design and conduct of the inquiry and the communication of results.
Coupled	A combination of two types of inquiry, for example a guided inquiry phase followed by an open inquiry phase.

Adapted from Pathway

Table 1: Levels of inquiry (Rooney 2012, p103).

2.4 Teachers' IBL Practices in Class

The calls for teaching the 21st century skills and the constructivist paradigm of learning have affected the teaching of all subjects including science. Learning that includes the ability to think and apply the scientific knowledge for individual and social purposes has replaced the old traditional practices that merely depends on memorizing and recalling facts (Chadwick 2014). The demanding fields for skilful members who are able to think critically, reason, communicate, and solve problems have forced changes in pedagogical practices (Bybee & Fuchs 2006; Chadwick 2014). Research shows that inquiry-based instruction is a more effective instructional strategy in science classrooms than the traditional knowledge transmission instructional strategy. It is a teaching approach and a learning goal at the same time (Anderson 2002, cited in Mumba et al. 2015).

Teachers who practice inquiry-based instruction in their lessons can improve students' science process skills, habits of minds, problem-solving thinking, and understanding of the nature of science. However, to implement inquiry-based instruction successfully, teachers require sophisticated and well-developed knowledge of inquiry (Miranda & Damico 2015).

Other research show that having the IBL knowledge does not necessarily mean practicing it, as the relationship between teachers' practical knowledge and their real practice in class is unclear (Meijer 2002). Different methods, such as field notes, interviews, journal writing and autobiography can be used to study this type of knowledge (Connelly 1997, cited in Ratinen 2015). However, for teachers to practice IBL in class, they need to allow their students to pose questions and predict answers through hypothesis, to conduct experiments and collect data, analyze and interpret data, and come up with their conclusions that might lead them to new questions (Rooney 2012). Furthermore, they need to provide more opportunities for students to explore the science content prior to explanation, to encourage and value the active student participation, provide opportunities to work collaboratively, and exhibit "guide on a side" teaching features (Miranda & Damico 2015). Figure (1) explains the inquiry cycle that teachers need to create in their class when they practice the IBL in science lessons.

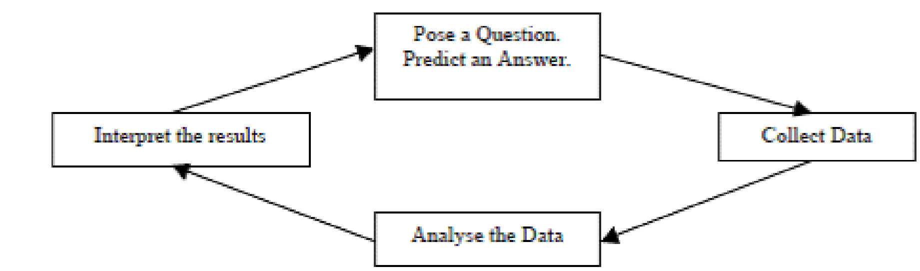

Figure 1: Inquiry cycle (Rooney 2012, p. 108).

Commonly, teachers' practices successfully change after attending PD programs (Zahid & Richard 2015). Science teachers are also affected by different types of PD programs, and their practices in class change after the intervention of these PDs such as IBPD (Gonzales 2013; Hall & Hord 2011; Kapanadze et al. 2015; Kazempour & Amirshokoohi 2013; Miranda & Damico 2015). After IBPD, teachers tend to engage their students more in inquiry-based student-centred activities, narrow their focus on factual knowledge and give their students opportunities to experience the IBL process in class (Kazempour & Amirshokoohi 2013).

2.5 Challenges in Implementing the IBL Approach

Most teachers do not use IBL in their classes due to a number of concerns including: unfamiliarity with how science is practiced or what inquiry is (Capps et al. 2012), lack of resources, time, and administrator support, in addition to pressure of standardized testing and coverage of materials (Gutierez 2015; Kazempour & Amirshokoohi 2013). Lack of time is a major obstacle to the use of inquiry in teaching science. Teachers' needs to mandate all the standards and prepare their students for tests force them to use the other traditional ways in teaching science rather than inquiry (Maxwell 2015). Kazempour (2009) adds that lack of funding for resources and the need to share materials are also obstacles in addition to lack of time, as they all frustrate teachers when applying the IBL approach in their lessons.

Lack of familiarity and knowledge in applying IBL is an important challenge in both middle and high school teachers (Capps et al. 2012). Moreover, students with language differences and learning disabilities are considered other challenges in teaching science in general and inquiry in specific (Buxton et al 2008, cited in Maxwell 2015). Teachers who taught students with learning disabilities often reported that they had a lack of content knowledge to succeed in teaching science (Aydeniz et al. 2012).

The IBL approach is a sophisticated and complex way of teaching and requires innovative science teacher education through professional development for both in-service and preservice teachers so they are able to develop their understanding of the science subject, the nature of inquiry, and how to apply it class (Capps et al. 2012). Teachers need to participate in quality PD programs to learn quality methods of science instruction to overcome these challenges (Maxwell 2015). PD for teachers is also recommended by Kazempour (2009) to improve their inquiry skills and face all the raised obstacles.

The main obstacles of applying the IBL in UAE are the unqualified teachers who are not ready to teach using such an approach, in addition to the socio-cultural factors such as religious and old fashioned beliefs in the society that lead to less inquiry in schools. Moreover, the lack of real contextual and cultural connection and the lack of follow-up and evaluation of many educational initiatives in addition to English language difficulties, especially in public schools, are other challenges for IBL development (Tairab 2010, cited in Mansour & Al Shamrani 2015).

2.6 The Results of Previous Studies

Many studies have discussed the importance of IBPD programs by utilizing surveys, interviews, classroom observation data, and pre- and post-PD experience to investigate teachers' perspectives, knowledge, and practices (Capps et al. 2012; Fortado 2010; Hall & Hord 2011; Marek et al 2003; Miranda & Damico 2015; Kapanadze et al. 2015; Kazempour & Amirshokoohi 2013).

Some studies focused on one area of development and a specific grade level, such as Fortado (2010) and Dolphin & Tillotson (2014). Furtado (2010) studied KG teachers' perceptions of the IBL pre- and post-professional development intervention using a quantitative survey and has stated that teachers' confidence increased significantly after attending the PD sessions. Dolphin & Tillotson (2014) studied the effect of training programs on teachers' beliefs through interviews. Other studies reviewed the empirical literature on IBPD and provided the best practices, such as Capps et al. (2012).

Kazempour (2013) investigated, through a case study, the impact of a course on science methods on an elementary teacher's confidence and attitudes towards science. Moreover, Kazempour & Amirshokoohi (2013) explored teachers' learning process and reflection during the PD. Choi & Ramsey (2009) studied the influence of IBL course on elementary teachers' beliefs, attitudes, and practical knowledge. They both found that the majority of the participants improved their knowledge and skills of conducting inquiry in their science teaching after these courses.

Chapter 3: Methodology

The present study investigates the effect of IBPD on teachers' attitudes, knowledge, and practices. Accordingly, it seeks to identify perceptions and best teaching instructional strategies that utilize the IBL approach in science lessons. This chapter will extrapolate the study approach including the site, sampling and participation, instrumentation, and ethical consideration. It also describes how reliability and validity were ensured through conducting a pilot study and obtaining the approval of experts.

3.1 Study Approach

A mixed method approach is used to collect data in this study. It combines both quantitative and qualitative data collection techniques. Different terms are used for this approach such as synthesis, integrating, and multimethod but recent writings tend to use the term mixed methods (Bryman 2006; Tashakkori& Teddlie 2010, cited in Creswell 2014). Qualitative data collection, through observations and interviews, and close ended, quantitative, through a questionnaire instrument are used to collect the data.

Fraenkel et al. (2015) presents that this approach first originated in the 1950s when some initial interests developed using more than one research method in a single study. Campbell & Fiske used multi measures in measuring traits. Qualitative and quantitative researchers have different beliefs and assumptions that guide the way they approach the investigation. They are different in their views of among other things, the nature of reality, and the process of research. Quantitative approach is related to the philosophy of positivism which emerged in the nineteenth century from Auguste Comte. This philosophy relies on empirical data and scientific method to produce effective knowledge (Creswell 2002). It requires collecting data through closed-ended questions, and using the statistical data to obtain generalizations and recommendations (Laban 2012). However, the qualitative approach is referred to as postmodernism which argues that all knowledge and truth are the product of history, power, and social interests (Cresswell 2014). These differences lead researchers to believe that the two methods referred to as "paradigm" have no middle ground to meet. In 1985, Rossman and Wilson referred to those researchers who stated that the two paradigms cannot mix as “purists” and those who believed that multiple paradigms can be used in one research as “pragmatists”. Pragmatists proposed that the researcher should use whatever works to answer the research question. Quantitative or qualitative approach can be used, or a combination of the two (Cresswell 2014).

The value of this approach lies in providing triangulation of the data source which reduces the bias and the weakness of a single method approach, as the combination of the two methods will supplement each other and balance each method’s respective weaknesses (Fraenkel et al. 2015). Moreover, the data provided by one approach will validate the other. Since the researcher has access to both quantitative and qualitative data, the mixed method seems to be the ideal approach to have a complete understanding of the question as it will provide a better explanation for the quantitative data by the qualitative, and it also offers better understanding for the experimental results based on participants’ perspectives. Furthermore, this method helps in obtaining different but complementary data on the same topic in order to deeply understand the research problem (Morse 1991, cited in Miranda & Damico 2015). The rationale for choosing this approach is to study in depth the relationship between conducting an IBPD program and improving teacher’s attitude, knowledge and practices in science lessons. It also can help to confirm or cross-validate relationships discovered between the previously mentioned variables.

Moreover, this approach poses some challenges such as the need of extensive data collection, the intensive time allocated to analyze both qualitative and quantitative data, and the need of being familiar with both quantitative and qualitative forms of research (Creswell 2014).

Convergent parallel mixed methods design is what the researcher conducts in this study. This applies to collecting and analyzing the qualitative and quantitative data separately and then comparing the results to see if the findings prove or disprove each other. The qualitative data provides participants’ detailed views, observed practices, and perspectives. However, the quantitative data provides the scores on the questionnaire instrument. Together they produce outcomes that should be the same (Creswell 2014). The integration of different types of data will help the researcher to gain perspectives to provide an overall combined evaluation of the study problem (Johnson & Christensen 2012). Both of the quantitative and qualitative approaches use the same variables and concepts. The close ended questions used in the questionnaire are turned into open ended questions and put to participants in interviews and are criteria in the observational check list. The data provided by the qualitative approach is smaller than the quantitative approach. The main purpose of having a smaller sample in the case of the qualitative approach is to gather extensive information from the participants (Creswell 2014). The study design is illustrated in Figure (2).

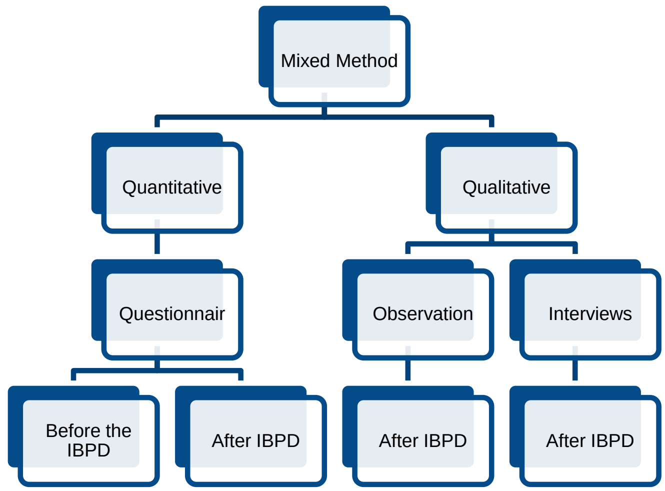

Figure 2: The mixed-method design steps

3.2 Sampling

The population is selected through a non-random sampling method. A convenience sample of teachers who teach science in one of UAE's K to 12 private schools is selected. The sample is available and feasible for the researcher who works as the Science Head of Department in the same school. All teachers who teach science from all grades, K through 12, participated in the study.

Overall 39 teachers participated from all grade levels. Teachers from K to grade 4 (Homeroom teachers) are teaching science in addition to math and English as core subjects. However, teachers from grade 5 to 12 are specialized science teachers who only teach science or other science core subjects such as physics, chemistry, and biology. The majority of participants are females and only three male teachers participated. The sample is representing the science teachers' male and female ratio in private schools in UAE to a certain extent, as teachers in the elementary phase are usually female homeroom teachers and male teachers usually teach middle and high school students in UAE's private schools. Teachers vary in their years of experience and subject knowledge. The demographic data such as gender, years of experience, highest obtained degree, major in the university, and taught subject are provided by the questionnaire. Sample size can be considered as one of the study limitations as it is less than 50.

3.3 Instrumentation

3.3.1 Quantitative Questionnaire

The researcher developed an instrument for the quantitative data collection in the form of a closed ended questionnaire. This instrument is adapted from previously used instruments in different research such as Kapanadze et al. (2015) and Farawi (2015, cited in Mansour & Shamrani 2015). The questions in the questionnaire are clustered in four areas: demographic data, attitude, perception of practices, and perceptions of knowledge (see Appendix 1). The first cluster is for the demographic information that was included to obtain participants' gender, highest obtained degree, taught grade level, the major at the university, years of teaching experience, subject they teach, and nationality. The second cluster is a perceptual scale that used the Likert scale to assess teachers' attitude and perceptions of practices before and after the IBPD. Teachers are asked to indicate their agreement with statements on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). In the third section, Yes/No/I don't know, questions aim to test teachers' knowledge about the IBL before and after attending the IBPD. The last section includes three open ended questions that explore other variables, such as: to what extent do teachers believe that the IBL is important in teaching science, the frequency of using this approach before and after the IBPD, and what are the main challenges faced by teachers when implementing the IBL in class. The instrument is used twice, before and after attending the IBPD. All participating teachers answered the questionnaire.

3.3.2 Observations

For the qualitative part of the study, observations were conducted in some classes by the researcher. Four teachers were selected, one from each phase, in order to obtain more extensive information about the questions asked in the questionnaire. Eight classes were observed randomly in both laboratories and classes of participating science teachers to understand the actual IBL practices that are implemented in their science lessons. Teachers have different academic qualifications (master in education, post graduate diploma, and bachelor degree). Elementary and

KG teachers teach science in addition to English and mathematics, as they work as homeroom teachers, and their specialty is not science. However, the middle and high school teachers are subject teachers who teach science only.

Observed teachers were informed in advance about the purpose of the observations and the identity of the researcher. Each teacher was observed twice in order to obtain more objective information and to reduce the researcher's bias (Frenkel et al. 2015). The duration of each observation was 45 minutes which is the time of one full period in the school. This considerable time allows the researcher to collect the copious amount of data and check the perceptions against what the data reveals (Fraenkel et al. 2015). Participant observation was conducted by the researcher. The focus of the observation was narrowed, as the main purpose of the observation was to investigate the effect of previously conducted IBPD on teachers' attitude, practices and knowledge. As there is no valid ideal method for collecting observational data (Flick 2014), the researcher designed an appropriate checklist for collecting the observational data that is aligned with the main focus of the study and the previously used quantitative questionnaire (see Appendix 2). The checklist included two sections. The first section investigates the use of IBL practices by the teacher in class. This part can reflect the observed teacher's practical knowledge and attitude about the IBL through the practices. The second part explain what type of inquiry was used. The appropriateness of the checklist was checked using the appropriateness suggestions mentioned by Flick (2014).

3.3.3 Interviews

Semi structured interviews in the form of a series of verbal questions (Fraenkel et al. 2015) were conducted with the same teachers who were observed. Specific questions were designed to elicit specific answers from teachers (see Appendix 3), mainly questions that investigate their attitude and perceptions of knowledge and practices obtained from the IBLPD. This type of social interaction provided by interviews is effective in collecting more qualitative data that is impossible to be obtained through observations only (Fraenkel & Wallen 2012). It will also check the accuracy of impressions gained through observations (Fraenkel et al. 2015). Teachers' perceptions and thoughts about the IBPD and their previous practices before attending the IBPD sessions are all areas that can be investigated through face to face interviews. Successful interviews rely on efficient investigative, and sequence of, questions (Cohen et al. 2000).

Required demographic information are asked at the beginning, followed by statements of the purpose and focus of the study, and ending with qualitative questions from general to more specific controversial questions. Different type of questions that investigate teachers' knowledge, expertise, practices, opinions, perspectives, and feelings are asked (Fraenkel et al. 2015). For the purpose of recording any useful non-verbal communication to ease data analysis, note-taking was used (McMillan & Schumacher 2010).

3.4 The Content of the IBPD Program

Teachers were engaged in a one week IBPD program that presented intensive information about the IBL approach. A number of hands-on activities and authentic experiences were implemented during the sessions. Teachers were working in collaborative groups where many opportunities for group discussion and group activities had been experienced. Analogies and role-play had been applied (see Appendix 5). All PD sessions were presented by the researcher who had prepared special PowerPoint presentations for this purpose (see Appendix 4). The first session was a presentation to familiarize the teachers with the IBL approach and enrich their knowledge about the main types of inquiry that can be used in education. The following-on sessions provided in-class short inquiry activities that can be implemented during science lessons in addition to a demonstration of a differentiated inquiry lesson. Teachers experienced the inquiry by acting as students and investigating differentiated inquiry activities. Another session was provided to link the IBL to the Science Fair project and explained how to use this approach in this event for different phases. A full month was given after the IBPD sessions for teachers to apply what they had learned in practice. Table (2) provides the main IBPD sessions' titles.

Session 1	Inquiry-based Learning knowledge enrichment
Session 2	Modeling IBL by demonstrating an authentic experience of this strategy in class
Session 3	In-class short inquiry activities
Session 4	Differentiated Inquiry Lesson
Session 5	Implement IBL in a Science Fair project

Table 2: IBPD sessions' titles.

3.5 Pilot Study

To guarantee the instrument's validity and reliability (Cresswell 2015) and due to the importance of the questionnaire's wording, to eliminate ambiguities in phrasing, and to improve the practicability (Cohen et al. 2000), the questionnaire was piloted and tested before being used for the actual study by asking 24 inexpert teachers and three expert teachers in IBL to see if the obtained data is consistent with the theoretical expectations. The rationale of this pilot test is to obtain more evidence for validity and reliability. Based on the pilot study some of the questionnaire questions were revised and changed to avoid clustering items in different scales. The researcher obtained the approval of a panel of experts, university instructor and a head of department.

The reliability level of the teachers' questionnaire was measured by SPSS software, and the measured Cronbach's Alpha = 0.77 indicates a high level of consistency for this questionnaire with a total of 38 quantitative questions. Furthermore, using mixed methods through triangulation of collecting data methods increases the validity. The researcher designed several instruments to collect the data which were useful to increase the credibility of the findings (Johnson & Onwuegbuzie 2004).

3.6 Ethical Considerations

Prior to conducting the study, the researcher obtained approval from the school director to gain access to the spot and study the participants. This permission involves a letter that explains duration, purpose, and the potential results of the research (see Appendix 6). Moreover, participants' approval to participate in the study is obtained (Creswell 2014). Teachers' approval is obtained prior to observation and interviews. Fraenkel et al. (2015) indicate that the researcher must provide complete information about all parts of the conducted study that might be of interest or concern to a participant. The researcher appropriately included brief information about the study attached to the distributed questionnaires, in addition to a verbal explanation of all study aspects to the participants of the study. Moreover, anonymity of participants and confidentiality of information obtained are guaranteed, as no names are included in the questionnaires' demographic description.

Chapter 4: Results and Data Analysis

The aim of the current study is to determine the degree to which applying IBPD enhances science teachers' attitudes, perceptions of knowledge, and practices when teaching science in their classes. This chapter presents the results analyzed from qualitative and quantitative data to investigate teachers' attitudes and perceptions of IBL elements, knowledge, and their implementation in classrooms after attending the IBPD. Teachers' pre- and post-PD data are compared and analyzed in addition to the qualitative results obtained through observations and interviews.

4.1 Demographic Information

Table (3) shows the demographic data from the first section of the teachers' questionnaire. Data reveals that the majority of the participating teachers are females and the minority are males. More than 50% of the teachers who participated in this study are teaching in the elementary phase (1-5). The majority of teachers hold a bachelor degree (71%). Teachers who have a scientific background as a major in the university are only 20%. 41% of the teachers had 3 to 5 years of teaching experience, however, 25.6% of teachers had more than 10 years. The majority (79%) of teachers are teaching science in addition to other subjects (homeroom teaching), while the rest teach science as a main core subject. Teachers came from different nationalities. 33.3% are Arabs and 66.7 % are non-Arabs with different nationalities such as South African, American, Afghani, Algerian, Lebanese, Jordanian, Palestinian, and Canadian.

The statistical results based on teachers' demographic information were analyzed (see Appendix 7). A one-way ANOVA test is used for the questions with more than two variables and t-test is used for questions with two variables. Data reveals that F value was statistically significant at the grade level variable, in the attitude area ($F=3.871$, $p=0.030$). KG and elementary teachers' attitudes have improved more than teachers of middle and high school. Another significant difference was found at the taught subject variable, specifically in practices ($t=3.360$, $p=0.030$).

Gender	Male	7.7%
	Female	92.3%
Grade Level	KG	20.5%
	1-5	51.3%
	6-8	17.9%
	9-12	10.3%
Highest Degree obtained	BA/BS	71.8%
	Higher Diploma	12.8%
	MA/MS	15.4%
	PHD	0.0%
Major in the University	Science	20.5%
	Others	79.5%
Teaching Experience	1-2	10.3%
	3-5	41.0%
	6-10	23.1%
	More than 10	25.6%
Subject taught	Science as a homeroom	79.5%
	General Science	5.1%
	Chemistry	7.7%
	Physics	5.1%
	Biology	2.6%
Nationality	Arabs	33.3%
	Non Arabs	66.7%

Table (3): Demographic data of participating teachers.

4.2 Teachers' Attitudes towards IBL Approach

This part of the questionnaire aims to explore the changes of all (N=39) teachers' attitudes after attending the IBPD program. Table (4) presents the means and standard deviations for both pre-IBPD and post-IBPD responses. The differences between the post- and pre- means and the significant difference of means (paired–sample t-statistic) for the key areas, related to attitude, are presented. T-test for means of paired samples is used to determine the p-value in order to identify any statistically significant values that reflect the differences of teachers' responses. The probability of any differences is measured by p-value which is significant only at $p < 0.05$. The first two rows in Table (4) compare the confidence of IBL knowledge and implementation that each teacher had pre- and post- the IBPD sessions. Before the PD, teachers had a mean level of 2.05 for their IBL knowledge confidence, which was raised to 3.08 after the PD. The same happened to the mean level for IBL implementation confidence as it raised from 2.36 (pre-IBPD) to 3.13 (post-IBPD). The mean difference t-statistic ($t=11.919$, $p=0.000$) for teachers' confidence of IBL knowledge is statistically significant and suggests that teachers are more confident of their IBL knowledge after the IBPD.

The same result is revealed for teachers' confidence of the IBL implementation, as the mean difference t-statistic (t=5.325, p= 0.000) is statistically significant and suggests that teachers are more confident of implementing the IBL approach after the IBPD. The negative t-value reflects that the post-IBPD mean is greater than the pre-IBPD mean, as the test is one-sided and the data is in a one-way direction. Therefore the absolute value was taken.

Question Items	**Pre-IBPD**		**Post-IBPD**		**Significant difference (Paired Samples T-test)**			
	Mean	Std. Deviation	Mean	Std. Deviation	**Mean Difference**	t-test	p-value	Significance
The confidence of the IBL knowledge	2.05	0.22	3.08	0.48	**1.03**	-11.919	0.000	Significant
The confidence of IBL implementation	2.36	0.58	3.13	0.62	**0.77**	-5.325	0.000	Significant
The effectiveness of IBPD	2.97	0.81	3.28	0.65	**0.31**	-1.821	0.076	Not significant
The interest to attend more IBPD	2.82	0.76	3.05	0.7	**0.23**	-1.325	0.193	Not Significant
Interest in the IBL	3.21	0.52	3.38	0.71	**0.17**	-1.125	0.268	Not Significant
The effectiveness of the IBL	3.28	0.69	3.38	0.75	**0.1**	-0.644	0.523	Not Significant

Table 4: Teachers' attitudes of IBL approach after attending IBPD

4.3 Teachers' Perceptions of the IBL Practices

This is the second cluster of the questionnaire data that aims to identify changes, if any, in teachers' perceptions of the IBL practices after attending the IBPD program. The data shows significant differences in most of the teachers' perceptions of the IBL practices when comparing their results pre- and post- the PD. The following practices have shown statistically significant difference using t-test; assessing the IBL practices using rubrics ($t=6.208$, $p=0.000$), planning an IBL lesson ($t=5.283$, $p= 0.000$), differentiating the practices when using the IBL approach ($t= 6.537$, $p= 0.000$), starting science lessons with a question ($t=2.773$, $p= 0.009$), applying the IBL approach when teaching science ($t= 2.688$, $p= 0.011$), being aware of all the IBL challenges ($t= 2.581$, $p=0.014$) , implementing a successful IBL lesson ($t= 2427$, $p= 0.02$), demonstrating how to use the IBL approach in class to colleagues($t= 2.883$, $p= 0.006$), allowing students to raise their own questions ($t=2.245$, $p= 0.031$), helping other teachers to plan for an IBL lesson ($t=2.179$, $p= 0.036$), and explaining every step when implementing the IBL approach ($t=7.471$, $p=0.000$). Moreover, areas related to facing and identifying challenges when implementing the IBL approach have shown no statistical significant differences as they had very low t-value and a p-value >0.05.

Question	Pre-IBPD		Post-IBPD		Significant difference (Paired Samples T-test)			
	Mean	Std. Deviation	Mean	Std. Deviation	**Mean Difference**	t-test	p-value	Significance
Assessing IBL using rubrics	2.23	0.49	3.15	0.75	**0.92**	-6.208	0.000	significant
Planning an IBL lesson	2.33	0.66	3.21	0.57	**0.88**	-5.283	0.000	significant
Differentiating the IBL lesson	2.13	0.34	3	0.8	**0.87**	-6.537	0.000	significant
Starting the science lesson with an inquiry question	2.72	0.83	3.21	0.7	**0.49**	-2.773	0.009	significant
Applying IBL when teaching science	2.82	0.64	3.28	0.61	**0.46**	-2.688	0.011	significant
Being aware of the IBL challenges	2.18	0.56	2.59	0.72	**0.41**	-2.581	0.014	significant
Implementing a successful IBL lesson	2.44	0.64	2.82	0.64	**0.38**	-2.427	0.02	significant
Demonstrate an IBL lesson	1.97	0.36	2.33	0.74	**0.36**	-2.883	0.006	significant
Allowing students to raise their own questions	2.92	0.7	3.26	0.6	**0.34**	-2.245	0.031	significant
Helping other teachers to implement IBL	2.23	0.63	2.56	0.85	**0.33**	-2.179	0.036	significant
Facing the IBL challenges	2.85	0.59	3.1	0.6	**0.25**	-1.885	0.067	Not Significant
Classroom management is a challenge when implementing IBL	3.23	0.67	3.26	0.68	**0.03**	-0.172	0.864	Not Significant
Explaining every step when implementing IBL	2.31	0.61	2.33	0.84	**0.02**	-7.471	0.00	significant
Resources availability is a main requirement for IBL	3.56	0.55	3.56	0.64	**0**	-0.177	0.86	Not Significant
Identifying time as a main challenge when implementing IBL	3.41	0.64	3.26	0.68	**0.15-**	1.098	0.279	Not Significant

Table (5): Teachers' perceptions of IBL practices after attending IBPD

4.4 Teachers' Perceptions of IBL Knowledge

This is the third cluster of the questionnaire that aims to measure the changes, if any, in teachers' perceptions of the IBL knowledge after attending the IBPD. Results show significant improvement of teachers' knowledge about the IBL approach after the PD in most areas. Eight out of ten areas showed statistical significant differences of mean t-statistic (t-value and p-values) after attending the IBPD, as their mean levels have risen when comparing the pre-IBPD means to the post-IBPD means. These areas are: identifying the number of different types of IBL approach (t=9.32, p=0.000), the meaning of "demonstrated inquiry" (t=5.39, p=0.000), identifying the IBL as a constructivist approach (t=2.9, p=0.006), identifying the meaning of self-directed inquiry (t=3.26, p=0.002), deciding whether self-directed inquiry is applicable when doing Science Fair projects or not (t=3.09, p=0.004), identifying the meaning of the words "independent variable" (t=2.9, p= 0.006), and recognizing the most common inquiry types in classes (t=2.88, p=0.006). Teachers' knowledge about these areas was less before attending the IBPD when comparing the pre- and post- means.

Question	Pre-IBPD		Post-IBPD		Significant difference (Paired Samples T-test)			
	Mean	Std. Deviation	Mean	Std. Deviation	**Mean Differen-ence**	t-test	P-value	Significance
The number of different types of IBL approaches	1.69	0.73	2.87	0.47	**1.18**	-9.32	0.000	Significant
The meaning of the demonstrated inquiry mean	2.26	0.75	2.92	0.27	**0.66**	-5.39	0.000	Significant
If the IBL is a constructivist approach	2.28	0.92	2.77	0.63	**0.49**	-2.9	0.006	Significant
The meaning of self-directed inquiry	2.41	0.79	2.87	0.41	**0.46**	-3.26	0.002	Significant
The applicability of self-directed inquiry in the Science Fair project	2.51	0.82	2.95	0.22	**0.44**	-3.09	0.004	Significant
The meaning of the independent variable	2.05	0.69	2.49	0.64	**0.44**	-2.9	0.006	Significant
The most common inquiry type in classrooms	1.97	0.54	2.33	0.48	**0.36**	-2.88	0.006	Significant
The use of demonstrated inquiry for students with average capability	2.13	0.61	2.38	0.75	**0.25**	-1.82	0.077	Not Significant
The applicability of scientific method when applying IBL approach	2.79	0.57	2.9	0.38	**0.11**	-0.89	0.378	Not Significant
The reason of using demonstrated inquiry in class	2.67	0.7	2.41	0.82	**-0.26**	1.4	0.168	Not Significant

Table 6: Teachers' knowledge of IBL approach after attending IBPD

4.5 The Overall Changes after Attending the IBPD

Figure (3) shows the overall results in the main clusters investigated in this study. Significant improvement in the three clusters is shown comparing the pre- and post-IBPD results. The most affected area is the teachers' attitudes to the IBL approach, followed by teachers' perceptions of practices and teachers' perceptions of knowledge respectively. The graph also reveals that teachers' knowledge and practices generally improved, based on mean, almost equally after attending the PD. Moreover, teachers' attitudes about the IBL approach were better, compared to their perspectives of knowledge and practices before attending the IBPD.

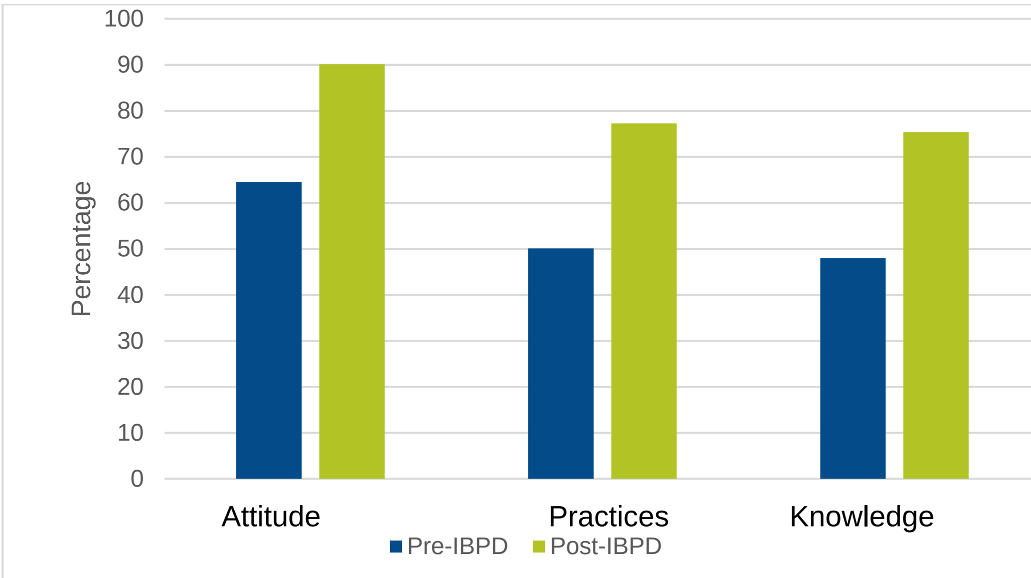

Figure 3: The overall % of improvement based on the quantitative data.

4.6 Teachers' Responses to the Qualitative Questions

The questionnaire included three open-ended qualitative questions to collect data in order to support the previous quantitative data and further explain major constructs of the study. The qualitative part of the questionnaire mainly investigated teachers' attitudes about the IBL approach, how often do they use this approach to implement their science lessons, and the main challenges they faced when they implemented the IBL approach. Teachers' responses after attending the IBPD were as following:

4.6.1 The Importance of IBL Approach in Teaching Science

Several different responses were presented. For example, teachers included:

"*IBL is important in teaching science because it allows students to explore, experiment, and find answers to their questions by themselves (Independent Learning).*"

"*I think it's very crucial when we teach science, because inquiry-based learning helps students to discover things on their own and allows the aspects of exploration to take place which plays a very important role in stimulating students' critical thinking.*"

"*It teaches our learners to become independent learners. It creates an environment where children want to learn, and they can relate their learning to real life.*"

"*It allows students to know why we teach science and how they can be able to solve any questions they have through science. It allows children to figure out their own questions through trial and error instead of being guided by the teacher.*"

Furthermore, most teachers stated that this approach helps the students to be independent learners, state their own questions, and be responsible of answering these questions through experimenting.

4.6.2 The Frequency of Implementing IBL Approach

The analysis of teachers' responses after the IBPD revealed that almost half of the participating teachers (n=18) are using the IBL approach in their science lessons on a daily basis. For example, teachers stated:

"*Almost every lesson, students need to be independent and know why they are doing this.*"

" *Every lesson starts with an inquiry question that students need to investigate*."

"*I try my best to implement it in all of my science lessons. When you hand students resources and let them derive the learning from their own discovery, students feel more confident and responsible for their own learning.*"

"Every day to keep the learners in the routine of doing it and to improve their skills at it."

Furthermore, some (n=9) admitted that they "try to implement it as much as they can" or "1-3 times a week". The remaining teachers' responses were either "hardly" or "once a week". The following are examples of these teachers' responses:

"*Hardly, restricted with time management, resources, narrow topics, textbooks, classroom management.*"

"*One lesson per week. It is a bit of a challenge.*"

"Sometimes, depends on the lesson."

"Only once a week. It is a bit challenging."

4.6.3 The Main Challenges when Implementing the IBL Approach

In this area, teachers' responses can be clustered under two main types of challenges. The first challenges are related to students such as their behavior, knowledge, language, and ability. The second changes are related to lesson planning, such as lack of resources and time.

Many teachers (n=18) stated that the main challenges that they had faced while implementing the IBL in their classes were related to limited resources and lack of enough time to implement the complete inquiry in their lessons. For instance, teachers answered:

"*I sometimes cannot find the right or enough resources for my lesson.*"

"*IBL* is *restricted with time management and resources.*"

"*Resources to allow the topic to be investigated to their fullest. Even if had or brought materials, there's no space or help to do lessons inside the class. Only once a week in the lab."*

Some teachers (n=12) raised other challenges related to their students ability, language, and knowledge. Teachers who stated the language as a barrier to implement the IBL approach explained:

"*Language difficulties. Children not knowing how to put their thoughts into words. They think too literally and not out of the box*."

"*Students' difficulty in expressing their understanding both orally and written. English language levels act as a barrier to class discussion.*"

Students' ability as a challenge was clear in other teachers' answers. For instance, they responded:

"*I just faced a problem with my lows since they are not able to figure things alone*."

"*Students, our students, may not be able to assume complete responsibility for their own learning. They need to be guided. They may not be able to raise questions for investigation or inquiry*."

4.7 Results of IBL Classroom Practices

The following table (4) illustrates the results of these observations that shed light on teachers' knowledge about IBL through planning and lesson preparation, practices through providing opportunities to students to follow the IBL steps, and attitudes through their role and flexibility while implementing this approach.

Teacher Knowledge	Teacher Practices	Teacher Attitudes
Lessons were planned in advance using the scientific method sequence. Ex: Lab lessons planned using the scientific method sequencing. 5 **Resources** 6 Materials are placed on Lab benches in six groups. 7 Extra materials were provided in some groups as distractors for the guided inquiry type. **8 Differentiation** Differentiated Lab recording sheets are provided to students. Both structured and guided. **9 Assessment** 10 Lab rubrics are attached to Lab reports to assess students' authentic practices. Rubrics criteria were written based on the	All lessons started with inquiry questions. Ex: - How can we calculate specific capacity? - Does the specific heat capacity of a substance depend on its molecular structure and on its phase? - Do bicarbonate ions help in maintaining the PH level in the presence of CO_2? **13 Scientific Method** Teachers provided opportunities to students to formulate their hypothesis, results, and conclusions as all Lab reports included the scientific method sequence and the teacher called for a presenter from each group to share the conclusion towards the end of the Lab. **14 Differentiated Inquiry** Differentiated inquiry opportunities were given to students. Ex:	Teachers seemed comfortable while teaching using the IBL approach in their classes. However, teachers with more experience seemed more comfortable. Ex: 16 Teacher used sense of humour with some students. 17 Teachers provided clear sequence for the lesson that allowed smooth inquiry process where everyone knows what to do. 18 Teachers had good classroom management. Students were aware of their roles and - Teachers acted as facilitators by guiding students when needed. No lecturing or dictating were observed.

steps of the scientific method (question, hypothesis, observation, data collection and analysis, conclusion, and communicating the results) 11 Teacher was scaffolding groups and providing feedback. **12 Time management** The time allocated for the inquiry activity was enough most of the time. All the inquiry steps were completed on time except for the last step (communicating the result) in some classes.	- Structured inquiry was applied as the inquiry question, materials, and experiment procedure were provided to students and they were asked to follow independently. - Guided Inquiry was applied by another group where only the inquiry question was provided in addition to different materials and students were asked to come up with the appropriate procedure to answer the question. - Teachers provided the autonomy to choose the type of implemented inquiry in some classes, however it was already chosen by the teacher based on students' abilities in other classes. **15 Collaboration** Techer allowed students to work in groups and asked them to follow the steps of the experiment in their Lab report.	- Teachers seemed organized and the lesson had a proper sequence that started with checking prior knowledge followed by the inquiry activity and ended with a short assessment. - Teachers provided constructive feedback for those students who struggled in applying the inquiry steps. - Teachers seemed happy as they were smiling and smoothly moving around the groups to provide guidance.

Table 7: Results of observed classes and Labs

4.8 Results from Teachers' Interviews

Four teachers had been interviewed for the purpose of supporting and further clarifying previous results, their attitudes about the IBL approach and how their knowledge and practices have changed after attending the IBPD sessions. Teachers were asked 11 questions and their recorded verbal answers are clustered mainly in four categories: teacher attitude, perception of knowledge, perception of practices and main challenges.

4.8.1 Teachers' Attitudes towards the IBL Approach

Teachers' responses under this category were mainly investigated through asking them questions about their feelings and confidence when teaching science using the IBL approach in addition to what extent their attitude changed after attending the IBPD. The data reveals that teachers enjoy teaching science and find it fun to teach. This is due to including many activities and real life connections in the lower grades. Higher grade teachers find difficulties sometimes due to the lack of responsibility of some students. All teachers admitted that it is not hard to teach using this approach if the appropriate knowledge and pedagogical practices and planning are available, in addition to resources.

The following are some examples from teachers' responses:

> *"It is not hard to teach, but you need to be aware of the content."*

> *"It is fun to teach if you have a proper lesson plan and resources.2*

> *"It is not hard if you know the content very well. If you are up to date in teaching strategies, you will make it enjoyable for students."*

Three out of four teachers assured that the IBPD program had changed their attitude and confidence when using the IBL approach in their lessons especially after gaining a great increase in knowledge and practicing it in their lessons. All teachers are interested in joining more IBPD programs. The following examples are quoted from their answers:

> *"Before I did not know how to use it in the lessons. Now after the PD and seeing it practically done, it is easy to implement."*

> *"At the beginning, I was not able to push them to discover or find things on their own. I learned a lot from them when they started to do so."*

> *"I feel at the end of every lesson that I am satisfied. Even if they [students] did not acquire the knowledge, I know that they had fun and they were involved. They are enjoying what they are doing."*

> *"My confidence escalated after gaining a vast knowledge."*

4.8.2 Teachers' Perceptions of IBL Knowledge

All teachers admitted that their knowledge of IBL approach had improved after attending the IBPD. They had very little knowledge about IBL and how to implement it. A high school biology teacher explained that she is aware of the scientific method but she did not know that it is the inquiry-based learning approach. The differentiated inquiry was a new topic that they had never come across before. The following statements demonstrate the improvement of teachers' knowledge after attending the IBPD:

> "*It improved a lot. My knowledge was the very minimum. I did not know the different types of inquiry. Now I know and understand them and am able to apply them effectively in my lesson plan and teaching. There is a pattern in teaching science that I did not know about before.*"

> *"I did not know that there are different types of inquiry nor the main steps of experimenting, but now I am aware of them. I can say for sure I know."*

> *"Yes it improved my knowledge, however, I did not apply it enough. I know how to search for inquiry activities now. I am on the right track."*

4.8.3 Teachers' Perceptions of IBL Practices

Teachers gained perceptions about applying and practicing the IBL approach in the teaching and learning process. They are able to plan and implement successful lessons, to a certain limit, using this approach. All of them mentioned that they did not previously apply it (IBl) as much as they do now. They still have some doubts about how successful their inquiry-based lessons are; however, they are working towards it. Some statements of teachers are as follows:

> "*Before, we tried to lecture and show things as they are. We did not give students chance to experience. We used to drill [information], but now we do experiments and students understand and observe. Questioning really helps in science.*"

> ***"****I am able to plan amazing lessons. I use what I have learned. I came up with nice ideas for my lessons that engage my students such as my lesson about adaptations and connecting birds' beaks to different tools."*

4.8.4 The Main Challenges Obtained through Interviews

All teachers identified some challenges they have faced when applying the IBL approach. They stated different challenges such as classroom management, the topic difficulty, getting easily distracted, students' different abilities, language, resources and familiarity with this approach. Higher grade teachers seemed more worried about resources than lower grade teachers who usually use simple and affordable tools. Teachers' responses in this area are clear in the following statements:

> "*When I leave my students to discover things, they lose focus and get out of the topic. The majority of my students are weak, so to keep them focused on the task is the challenge. They play with the resources.*"

> *"Classroom management. Our students are curious in a negative way so it turns to chaos at some points. The second challenge is the lesson itself. It is hard to find inquiry activities for some topics."*

> *"First of all, the language. Grade 1 students do not understand the words and steps of inquiry. Sometimes structured inquiry is better than guided, especially at the beginning."*

> *"The first challenge is that students are not familiar with differentiated inquiry. Tools of experiments are hard to find.*

Chapter 5: Discussion, Conclusions, and Recommendations

This chapter discusses and interprets the findings presented in the previous chapter. Final conclusion, recommendations, and the study limitations are all presented in this chapter.

5.1 Discussion

Both qualitative and quantitative data will be discussed to answer the main questions presented by the study. The main findings revealed in the three main areas investigated will be discussed thoroughly. The effects of IBPD on teachers' attitudes, knowledge and practices will be discussed based on the multiple instruments' data that was obtained to overcome the difficulty of measuring skills (Lai & Viering 2012).

5.1.1 Teachers' Attitudes towards the IBL Approach

Attitudes towards IBL had obviously improved after attending the IBPD. Teacher's confidence of their knowledge and how to implement this approach had increased based on the obtained quantitative and qualitative results. These results proved that the IBPD had a significant effect on the level of confidence in implementing the IBL approach which matched the results of other studies (Furtado 2010; Tatar & Buldur 2013). The improvement of teachers' attitude after attending the IBPD is the highest when compared to their perspectives of knowledge and practices. This is due to the high level of positive attitude towards the IBL approach even before attending the PD. However, this result cannot guarantee the successful implementation as intensive authentic practices are necessary to contribute efficiently to teachers' practices (Al-Shannag et al. 2013). This was revealed in the quantitative interviews, as teachers proclaimed their doubts in implementing successful inquiry lessons despite their improved confidence attitudes towards the IBL approach.

The increased confidence is due to the increased satisfaction feelings about teaching science lessons after the IBPD, as teachers stated when they were interviewed. This is due to the increasing self-efficacy provided by the PD (Tatar & Buldur 2013). Moreover, the collaboration opportunities provided during the PD program will help teachers to construct a rationale for their decisions (Lyngved et al. 2012) and reduce the anxiety level of adopting the IBL in the classroom (Furtado 2010).

Teachers' confidence escalated after gaining the appropriate knowledge about IBL, as they have stated in their qualitative responses. Providing content knowledge and the engagement in practical experience through the PD program had changed teachers' attitude towards this approach and lead to an enjoyable experience in class as their concerns reduced and ample information was provided to ease the implementation (Furtado 2010).

The obtained results show that the teachers of the lower grades (KG and elementary) had better improvement in attitude towards IBL after attending IBPD than higher grade teachers as they started with a less positive attitude and interest towards IBL than the higher grades prior to the IBPD. This result agrees with many research results, which claim that elementary and KG teachers lack exposure to and experience with IBL (Choi & Ramsey 2009; Chung Lee 2011; Fortado 2010; Gonzales 2013; Ratinin et al. 2015).

5.1.2 Teachers' IBL Practices

The results of changes in teachers' practices have been obtained based on teachers' perceptions through the quantitative questionnaire, the qualitative written responses in the questionnaire, and the interviews. However, the authentic practices were monitored and recorded through observations.

The obtained results showed that teachers' perceptions and authentic practices of IBL had improved significantly in most categories. Teachers' quantitative results are consistent with their qualitative written and verbal responses and observed practices. Usually, teachers' practices successfully change after attending PD programs (Zahid & Richard 2015) as they tend to engage their students more in inquiry-based student-centred activities (Kazempour & Amirshokoohi 2013). Teachers start their lessons with inquiry questions, allow their students to state a hypothesis, and conduct experiments, collect data to find answers for their questions, and these are the main practices of the IBL approach (Rooney 2012). Kazempour & Amirshokoohi (2013) presented similar results that indicate improved practices reported by other studies.

Teachers use rubrics with certain criteria that assess the students' performances based on the scientific method steps. Such authentic tasks are often assessed using rubrics that state evaluation criteria for students so they can use theses for self-assessment in addition to teachers' assessment

(Montgomery 2012). Students-centred lessons are planned to allow students to investigate and collaborate. Differentiated inquiry activities in some lessons were observed by providing students with inquiry activities differing in their level of complexity. The observed differentiated lessons were tiered lessons as the same content and learning goals were addressed (Tomlinson 1999, cited in Whitworth et al. 2013). This area was one of the most significantly improved areas, based on the teachers' perceptions of practices, as most teachers explained that they were previously unaware of how to differentiate the inquiry-based lessons. Even those who had good knowledge about the approach before the PD used to apply one inquiry type; however, using the differentiated inquiry means constructing an investigation with multiple or tired levels of guidance so that each learner has to choose a level that is appropriate for his or her particular learning style (Llewellyn 2011).

The frequency of practicing IBL in science lessons improved significantly; however, some teachers admitted that they are not applying it as they should. Although they have good attitudes towards IBL approach this does not match their practices. This result is evident in the research of Bryan (2003). Teachers' instructional decisions after attending the PD programs do not necessarily mean that they will start practicing upon returning to the classroom (Kazempour & Amirshokoohi 2013).

An interesting result from this study is that there is an apparent significant statistical difference in the improving practice of IBL based on teachers' subject taught. Teachers who teach science as a main subject, who usually came from scientific background as their university major is scientific, practice more inquiry in their science lessons than homeroom teachers, who teach science in addition to math and English in the elementary and KG sections. Research shows that elementary teachers usually practice less inquiry in their lessons as they lack the familiarity of scientific inquiry and Inquiry-based instruction (Kennedy 1998, cited in Capps et al. 2012). They do not have the adequate background or pedagogical skills required to teach science to the level it needs to be taught (Furtado 2010).

5.1.3 Teachers' Knowledge of IBL

According to the data revealed in this study, teachers' knowledge of IBL approach has shown significant improvement after attending the PD sessions. This improvement is consistent when comparing all data obtained using the different approaches in this study. Teachers were unaware of the differentiated inquiry approaches before attending the PD sessions. Research shows that doing experiments alone does not lead to better outcomes for students. In order to support students' inquiry learning, teachers must be aware of the different phases and aspects of inquiry as it has different levels of openness (Banchi & Bell 2008). They did not know that inquiry in science is about following scientific method, as one of the interviewed teachers claimed. The result of this poor knowledge was less inquiry in classes (Tairab 2012). However, after attending the IBPD sessions their knowledge level of IBL had increased which apparently affected their instructional practices later. According to Chung Lee (2011), teachers need to develop their own understanding of inquiry before they can start guiding their students to apply it. Engaging science teachers in PD sessions will affect their knowledge and decisions so they choose to use an IBL approach when teaching (Choi & Ramsey 2009).

Teachers' improved knowledge has affected their attitude about the IBL approach. This result was clear in teachers' responses through the interviews, as they indicated that they started to be comfortable and more confident when applying this approach after gaining the appropriate knowledge about it. Providing teachers with inquiry-based PD alters their concerns and confidence, reduces perceived doubts, provides enough information to ease the implementation and decreases the anxiety level of adopting the IBL in the classroom (Furtado 2010). Moreover, teachers' improved knowledge of the IBL approach had positively affected their practices and readiness for their inquiry lessons in class and labs. Their lessons were written from inquiry perspectives based on the scientific method steps and they involved students in collaborative activities where their roles became more guiding than lecturing. When teachers' knowledge about IBL is enriched through PDs, their role in class changes to be "a guide on the side" rather than "a sage on the stage" (Gonzalez 2013). Kazempour (2009, cited in Maxwell 2015) states that science teachers need to guide and facilitate the learning and students need to take an active role in constructing their own knowledge.

5.1.4 Main Challenges when Implementing the IBL Approach

Teachers' responses about the main challenges they face when applying the IBL approach were mainly obtained from the qualitative written part of the questionnaire and teachers' interviews. All teachers admitted that they had faced challenges when implementing the IBL approach in their science lessons. Four main challenges were obvious in teachers' responses: resources, time management, language barrier, and students' ability were the major concerns of teachers according to the revealed data in this study. Lack of appropriate teaching materials is a dominant problem for the implementation of IBL in addition to the needed time to apply proper inquiry lessons (Gutierez 2015; Kazempour & Amirshokoohi 2013). Maxwell (2015) states that one of the major obstacles to using inquiry while teaching science is the more time needed to cover the scientific knowledge when using this approach. Teachers are overwhelmed and need to mandate all standards and prepare their students to internal and international tests so they choose to lecture to manage all that is required from them (Maxwell 2015). In UAE schools, parents' resistance to the new teaching approaches and their focus on the end of term exams and results that can be guaranteed through the traditional directed teaching approaches are other factors that may delay the IBL (Mansour & Al- Shamrani 2015).

The study revealed that lack of the proper inquiry resources is another major challenge that slows down using inquiry in science lessons. This challenge was more obvious in the response of high and middle school teachers as the lab materials are more complicated and expensive for higher grades experiments. However elementary inquiry resources are more affordable and can easily be brought from home or grocery stores. Kazempour (2009) indicates the same challenge and explains that the lack of funding for resources and the need to share materials can prevent teachers from applying an IBL approach in their classes.

The level of students' English language is a challenge raised by many teachers, especially the elementary teachers (1-5). Teaching students with language differences is considered another challenge in teaching science in general and inquiry in specific (Buxton et al 2008, cited in Maxwell 2015). This is a major cause of concern in UAE government schools where students are less exposed to the language; however, this should not be the case in UAE private schools as the English language is used as the medium for delivery of all the subjects, except for the Arabic language and Islamic studies (Mansour & Al Shamrani 2015). Another main challenge raised by this study is the difficulty of applying this approach with the below-level students who either have learning difficulties or disabilities. Teachers who taught students with learning disabilities often reported that they lacked content knowledge to succeed in teaching science (Aydeniz et al 2012).

5.2 Conclusion

This study was conducted to investigate the effect of science inquiry-based professional development (IBPD) on teachers' attitudes, knowledge, and practices in UAE. The study found that after attending the IBPD program teachers' attitudes, knowledge, and practices when using this approach have positively and significantly improved.

Teachers' attitudes had shown the most improvement, compared to their knowledge and practices. Teachers became more confident of their knowledge and practices of how to apply the IBL approach in their lessons. This confidence was reflected in their observed lessons as they seemed flexible and comfortable when teaching their science lessons using the IBL approach. Their anxiety levels were reduced and they started to use more inquiry in science lessons (Furtado 2010). KG and elementary teachers' attitudes rose significantly more than high and middle school teachers' after attending the IBPD. This is due to the lack of their IBL knowledge and how to practice it before attending the PD (Choi & Ramsey 2009; Chung Lee 2011; Fortado 2010; Gonzales 2013; Ratinin et al. 2015).

Teachers' practices after attending the IBPD reflected clear inquiry instruction in both their lab and science lessons. These practices are consistent with their perceptions about their inquiry practices that were stated in their quantitative responses and interviews. Students were given many opportunities to practice inquiry while learning science. Differentiated inquiry tasks were designed for students with different abilities. More guided inquiry was applied for those who needed it and the choice was given to students to practice open inquiry in some classes. Lessons are designed from the scientific method perspective. Students were given the chance to hypothesize, conduct the experiment, collect and analyze data, come up with conclusions, and communicate their results. Teachers allowed students to raise their own questions and work in collaborative groups. Inquiry activities were assessed using specific inquiry rubrics. Middle and high school teachers practice more inquiry in their science lessons than KG and elementary, however, the last group had better attitudes towards the IBL approach after attending the IBPD program. This is due to the KG and elementary teachers' lack of experience in applying the IBL approach and their poor scientific knowledge compared to the teachers of middle and high school. These teachers need more time to retain the new learned knowledge of IBL and more time to practice it in class (Kazempour & Amirshokoohi 2013).

The amount of knowledge obtained after attending the IBPD program had improved in all phases. Many inquiry jargons such as: inquiry-based learning, self-directed inquiry, demonstrated inquiry, and variables, were unfamiliar to many teachers before attending the PD sessions. The practical knowledge to apply the differentiated inquiry was highly appreciated by most teachers. This newly gained knowledge about the IBL approach positively affected teachers' attitudes and practices when teaching science using this approach (Furtado 2010).

Furthermore, the findings of the study also present the main challenges faced by the teachers when implementing the IBL approach, such as: time limit, shortage of resources, students' English language proficiency, and teaching inquiry to students with disabilities and learning difficulties.

To sum up, inquiry-based learning professional development (IBPD) is important for science teachers to improve their attitude, knowledge, and practices when teaching science using the IBL approach. Teachers who attended IBPD sessions had positive perceptions about using IBL in their lessons as they started to engage their students in inquiry activities more frequently and professionally. Their self-efficacy had been improved as they became more confident of their success in implementing these types of lessons. The amount of knowledge they had gained after the PD had been developed and was reflected in their attitudes and practices. Teachers faced some challenges when implementing the IBL, such as: time and resources shortage, English language proficiency, and using this approach while teaching students with learning difficulties and disabilities.

5.3 Recommendations

This study has two main types of recommendations; one is related to teachers' development and the other in promoting further educational research raised by the study.

5.3.1 Recommendations Related to Developing Teachers' Performances

IBL is considered the innovative approach to teach science nowadays. Engaging teachers in authentic experiences to practice the inquiry through an IBPD program is important to improve their knowledge and practices when using this approach to teach science. The following are important recommendations that should be taken into consideration based on the main findings of the study:

- Extend the PD program by conducting continuous professional development (CPD) sessions related to inquiry so teachers can gain the complete knowledge about how to apply this approach.
- Allow teachers to practice what they have learned after the IBPD by providing ample time to try the IBL approach and reflect on it.
- Provide teachers with the necessary resources and support to apply the IBL approach when teaching science.
- Modify the science curriculum by decreasing the content and considering the time when planning inquiry lessons that enhances the investigation skills of our students.
- Provide grade-appropriate demonstrated inquiry lessons for KG and elementary teachers to facilitate and improve their inquiry practices in class.
- Provide IBPD sessions from an inclusion perspective to support teachers who teach students with special needs and learning disabilities.

5.3.2 Recommendations Related to other Research

This study has investigated the effect of IBPD programs on teachers' attitude, knowledge, and practices. The significant positive relationship between the IBPD programs and teachers' attitudes, knowledge, and practices that appeared in this study would require further research in order to follow up the indirect effect of the IBPD program on students' achievements. It also requires further investigations to study the effect of IBPD programs on teachers who deal more with students with special needs, as this concern was raised in some teachers' responses in this study. The study can also be extended by suggesting more items related to attitude, knowledge and practices that can be investigated using the same approach. Further research is required to investigate the effect of longer IBPD programs that allow more time for practice and reflection.

5.4 Limitations

The study has limitations due to the small size of the sample and small number of observed classes and conducted interviews. Therefore, the results cannot be generalized to all of the UAE. Randomization was not possible as participants were intact and fixed. Random selection of participants would provide more accurate results. Only 39 teachers who teach science in the same school participated in this study. The majority of the participating teachers are female. Only three male teachers participated in this study. The majority of the participating teachers teach science in the elementary phase while the number of middle and high school science teachers is very small and this might create a sampling error.

The PD allocated time is considered short to obtain accurate results. Only five days of PD sessions were conducted to familiarize the teachers with the IBL approach and improve their IBL pedagogical knowledge and practices. However, more CPD is required with longer allocated periods of time, so teachers have a complete grasp and understanding of the new practice. Moreover, the researcher works at the same school as the science head of department, and this might reduce teachers' autonomy to show their real attitude and perceptions about the IBL approach, as it is highly recommended by the researcher when teaching science in the same school.

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Appendices

Appendix 1: Teachers' Questionnaire

IBL-Professional Development Questionnaire

Instructions: This questionnaire elicits your opinion on teacher's Inquiry-based Learning (IBL) professional development. This collected information is treated with confidentially. Data is gathered through an online link which does not identify participants or their schools. Your participation is completely voluntary. Please respond to the four sections below with your best knowledge and opinion.

A- Demographic Information

1.	Please indicate your gender.	Male □	Female □
2.	Please indicate the grade level you teach.	KG □ 1-5 □ 6-8□ 9-12□	
3.	What is the highest degree you hold?	BA/BS□ Higher Diploma□ MA/MS□ PhD □	
4.	What was your major in University?	Science □ others□	
5.	What years of teaching experience do you have?	1-2□ 3-5□ 6-10□ More than 10□	
6.	What subject do you teach?	Science as a Homeroom□ General Science□ Chemistry□ Physics□ Biology □	
7.	Nationality		

B- For the following items, please mark the box with your appropriate response as:

1- Strongly Disagree (SD)
2- Disagree (D)
3- Agree (A)
4- Strongly Agree (SA)

No	Statement	Response 1 2 3 4 SD D A SA
8.	Inquiry-based Learning (IBL) is an interesting topic.	□ □ □ □
9.	Inquiry-based Learning (IBL) is not an effective teaching strategy.	□ □ □ □
10.	I apply the Inquiry-based strategy when teaching science.	□ □ □ □
11.	Time management is one of the challenges in implementing the Inquiry-based Learning (IBL).	□ □ □ □
12.	Resources availability is one of the important requirement for a successful Inquiry Based Learning lesson.	□ □ □ □
13.	Classroom management is one of the challenges in implementing the Inquiry Based Learning approach.	□ □ □ □
14.	Professional development in Inquiry-based Learning (IBL) will assist me to understand this approach.	□ □ □ □
15.	I would like to attend professional development sessions about Inquiry Based Learning.	□ □ □ □

16.	I do not know exactly how to implement the Inquiry Based Learning in my class.	SD D A SA ☐ ☐ ☐ ☐
17.	I can explain the different types of Inquiry Based Learning.	☐ ☐ ☐ ☐
18.	I plan an Inquiry Based Learning lessons when I teach science.	☐ ☐ ☐ ☐
19.	I assess the student's Inquiry Based skills using the rubric.	☐ ☐ ☐ ☐
20.	I differentiate the Inquiry Based Learning lesson in my science lessons.	☐ ☐ ☐ ☐
21.	I implement a successful Inquiry Based Learning lesson in my class.	☐ ☐ ☐ ☐
22.	I help other teachers to implement plan the IBL lessons.	☐ ☐ ☐ ☐
23.	I demonstrate a lesson about how to implement Inquiry Based Learning in class to my colleagues.	☐ ☐ ☐ ☐
24.	I explain every step to my students when I implement the Inquiry Based Learning.	☐ ☐ ☐ ☐
25.	I allow my students to raise their own questions when implementing the Inquiry Based Learning.	☐ ☐ ☐ ☐
26.	I always start the IBL lesson with a question and ask my students to answer it by investigation.	☐ ☐ ☐ ☐
27.	I am not aware of all the IBL challenges.	☐ ☐ ☐ ☐
28.	I cannot face the Inquiry Based Learning Challenges.	☐ ☐ ☐ ☐

IB: Inquiry Based IBL: Inquiry based learning

C- For the following items, please mark the box with your appropriate response as:

1. **Yes (Y)**
2. **No(N)**
3. **I don't know (IDN)**

No	Statement	Response 1 Y	 2 N	 3 IDN
29.	There are two types of inquiry	☐	☐	☐
30.	The demonstrated inquiry is student-initiated	☐	☐	☐
31.	In the self-directed inquiry, the teacher initiate the full inquiry.	☐	☐	☐
32.	The most common inquiry type in our classes is the guided inquiry.	☐	☐	☐
33.	In Inquiry Based Learning, students apply the scientific method steps.	☐	☐	☐
34.	For the Science Fair inquiry projects self-directed inquiry is highly recommended.	☐	☐	☐
35.	Teachers use demonstrated inquiry due to limited time and resources.	☐	☐	☐
36.	Demonstrated inquiry is suitable for students with average capability	☐	☐	☐
37.	Inquiry Based Learning is not a constructivist approach in learning	☐	☐	☐
38.	The independent variable is the variable that changes in the experiment.	☐	☐	☐

D- Please answer the following questions:

38. In your opinion, to what extent do you think IBL is important in teaching science?

....
....
....
....
....
....

39. How often do you implement the IBL in your science lessons? Why?

....
....
....
....
....
....

40. What are the main challenges you have faced while implementing inquiry based learning in your class?

....
....
....
....
....
....

Thank you very much for your cooperation!

Appendix 2: Observation Checklist

الجامعة البريطانية في دبي

The British University in Dubai

Class Observation Check List

Teacher		**Level/Class**	
Lesson Title			

Teacher's practices		**Comments/ Notes**
Preparing resources for inquiry investigation on tables		
Lesson is planned using the scientific method sequence		
Allowed students to pose their own questions		
Acting as a facilitator by planning a student centered lesson		
The lesson starts with the inquiry question.		
Allowing students to generate their hypothesis		
Allowing students to investigate their question by applying a scientific experiment		
Allowing students to observe and collect data		
Allowing students to make conclusion		
Allowing students to communicate their results		
Differentiated inquiry is implemented		
Lesson is completed on time		
Teacher provide scaffolding during investigation		
Rubrics are shared with students to assess their inquiry performances		
Teacher seemed comfortable using the IBL approach		

Type of Inquiry used		**Comments / Note**
Demonstrated		
Structured		
guided		
Self-directed		

Appendix 3: Interview Questions

Interview Questions

Name		Grade Level	
Highest Degree		Major in University	
Years of Experience		Subject	
Nationality			
Date			

1. How do you feel about teaching science in general?

   ....

2. Is science hard to teach? Why?

   ....

3. Did you know about IBL before the PD?

   ....

4. Did the IBPD change your perceptions about teaching science? How? What was is like before and after?

   ....

5. Did the IBPD improve your knowledge about the IBL approach? Explain. What was is like before and after?

   ....

6. Did the IBPD improve your confidence of using this approach when teaching science? Explain. What was it like before and after?

   ....

7. Are you able to plan a lesson using this approach (IBL)?

   ....

8. Are you able to implement a successful IBL lesson in your class? To what extent?

   ....

9. What are the main challenges you face when implementing IBL in your science lessons?

   ....

10. Are you interested of joining more PDs about IBL?

    ....

11. Is it easy to find resources for implementing IBL approach easy?

    ....

Appendix 4: Sample of the IBPD PowerPoint Presentation

Questionnaire

Inquiry Based Learning IBL

TEACH, PRACTICE, ASSESS

RANIA AMAIREH

Learning Science by Doing

If you Tell me …I might forget

If you show me…..I will remember

If you involve me….I will never forget.

Question Based Learning

Focus on a question and see if that question is investigatable

The Scientific Method

The Scientific Method

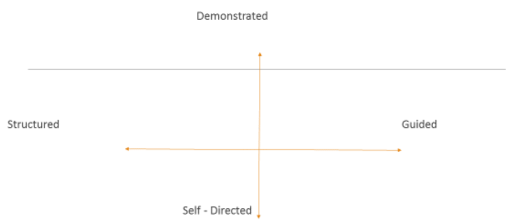
Seven Segments of Inquiry

1. The question
   - a. Exploring a phenomenon
   - b. Focusing on a question
1. The procedure
   - a. Planning the investigation
   - b. Conducting the investigation
1. The result
   - a. Analyzing the data and evidence
   - b. Constructing New Knowledge
   - c. Communicating New Knowledge

Variables

Dependent

Independent



Types of Inquiry

	Demonstrated IBL	Structured IBL	Guided IBL	Self Directed
Pausing the question	Teacher	Teacher	Teacher	Student
Planning the Procedure	Teacher	Teacher	Student	Student
Analyzing the result	Teacher	Student	Student	Student

Demonstrated Inquiry

Teacher's Role	Student's Role
• Introduces the new concept • Poses questions and elect responses to ass students understanding. • Models appropriate scientific and safety procedure. • Uses show and tell modes of instruction	• Connect new observations to prior experience. • Takes notes and provides a justifiable explanation to observations. • Builds and elaborate upon the observations and explanation of others.

Structured Inquiry

Teacher's Role	Student's Role
• Provides step by step sequential procedure. • Provides materials and supplies as listed in the Lab sheet. • Assign roles to students on a rotating base. • Act as a coach to make sure everyone is on task • Encourage students to work in groups. • Ask probing questions and answers questions when appropriate. • Provides follow up and going further inquiries.	• Obtain materials and supplies as listed on Lab sheet. • Reads and follows directions according to activity sheet. • Uses scientific method to collect data. • Communicate and collaborate • Makes observations, collect data, design data charts and tables. • Looks for patterns and relationship in data • Draws conclusions and communicate results. • Ask new and related questions

Guided Inquiry

Teacher's Role	Student's Role
• Provide a problem or a question to investigate • Encourage students to design means to solve the problem. • Act as a facilitator to the problem solving process. • Encourages accountability and sharing decision among group members. • Poses questions and prompts to extend thinking. • Directs students to other resources	• Define the nature of the problem • Brainstorm and generate the procedure. • Selects and design a plan. • Selects appropriate materials • Implement the plan to answer the question. • Uses scientific method to collect and analyze data. • Communicate and collaborate. • Makes observations. • Designs data charts

Self-Directed Inquiry

Teacher's Role	Student's Role
• Provide an open ended exploration to initiate questions. • Acts as a mentor to help students answer their questions • Assist in providing supplies. • Poses additional questions to elaborate the inetial question. • Organize a mean for students to communicate. • Assesses students' ability to self directed learners	• Makes initial observations that drives personal questions • States the question and takes ownership of the question. • Identify variables for the question • Construct a hypothesis, Designs procedures, determine equipment, design data chart and draw conclusions • Evaluate and communicate the result. • Ask new questions based on the

Guess what type of Inquiry?

a. Teacher
S S S S S S S
S S S S S S S
S S S S S S S

b. S S S
S Teacher S
S S S

S S
C. S S
Teacher S
S S S

D. S S S
S Teacher
S S
S S S

4 Stations

Each station will have a different learning approach.

Station 1 (Demonstrated) will investigate how does the ramp height affect the distance that distance a marble will travel? Teacher will demonstrate the experiment and you will help her in conducting the experiment and collecting the data.

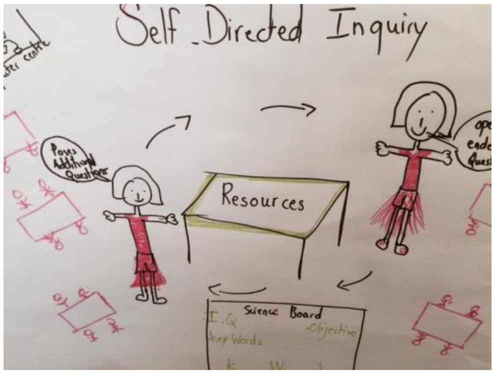
Station 2 (Structured) you have a the materials and the procedure steps. Go through the experiment sheet and conduct the experiment and collect the data.

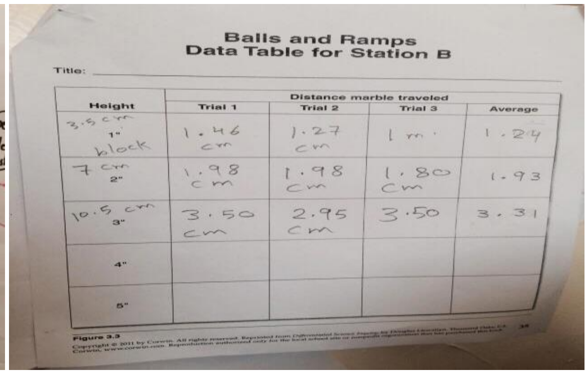
Station 3 (Guided) you have the materials in front of you, design and carry out a procedure that will answer one of these questions (choose one task)

1. how does the ramp height affect the distance that distance a marble will travel?
2. How would the size of the marble affect the distance a marble will travel?
3. How would the ramp height affect the time a marble will travel?

Station 4 (Self Directed). You have the following materials. Come up with your own questions and carry out an investigation to answer the question.

Appendix 5: Sample of Teachers' Cooperative Work during the PD

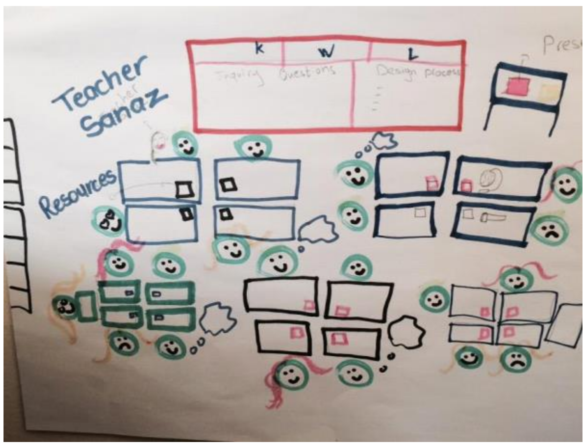



Balls and Ramps
Data Table for Station B

Title:

Height	Distance marble traveled			
	Trial 1	Trial 2	Trial 3	Average
3.5 cm 1" block	1.46 cm	1.27 cm	1 m.	1.24
7 cm 2"	1.98 cm	1.98 cm	1.80 cm	1.93
10.5 cm 3"	3.50 cm	2.95 cm	3.50	3.31
4"				
5"				

Figure 3.3



Appendix 6: Permission Letter to the School

الجامعة البريطانية في دبي

The British University in Dubai

www.buid.ac.ae

30 November 2015

To Whom it May Concern

This is to certify that **Ms Rania Suleiman Amaireh – Student ID No. 2014101062** is a registered full-time student on the **Master of Education (following the pathway in Management Leadership and Policy)** programme in **The British University in Dubai**, from **September 2014**.

Ms Amaireh is currently working on a dissertation as part of the programme requirements. She is required to gather data by conducting a questionnaire surveys, interviews and classroom observation. Any support provided to her in this regard will be highly appreciated.

This letter is issued on Ms Amaireh's request.

Yours sincerely,

Amer Alaya
Head of Student Administration

13-3-16

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Appendix 7: Teachers' Results based on the Demographic Information

Demographic Variables		Type of test	(F-test)	Alfa	Significant	Rank (Tukey) (Max to Min)
Grade level you teach	attitude	1-way ANOVA	3.871	0.030		KG = 1-5 6 -12
	Practices		0.969	0.389		No different
	Knowledge		2.424	0.103		No different
Years' Experience	Attitude	1-way ANOVA	1.067	0.375		No different
	Practices		1.721	0.181		No different
	Knowledge		1.472	0.239		No different
Degree	Attitude	1-way ANOVA	1.552	0.226		No different
	Practices		1.438	0.251		No different
	Knowledge		1.557	0.225		No different
Subject teaching	Attitude	1-way ANOVA	2.058	0.124		No different
	Practices		3.360	0.030		GS Physics SH Chemistry
	Knowledge		1.999	0.132		No different
Nationality	Attitude	Independent sample T-test	-1.593	0.120		No different
	Practices		-0.756	0.455		No different
	Knowledge		-1.298	0.159		No different