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# Provision of Inquiry Instruction and Actual Level of Practice as Perceived by Science Teachers and their Students

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**ABSTRACT**
The purpose of this study was to examine science students' and teachers' views of the provision and implementation of inquiry-based instruction in UAE secondary school science classes. Two instruments were developed and validated to collect participants' views of the provision and practice of inquiry-related activities. The findings suggested that both students and teachers believed that the curriculum materials lend themselves to supporting inquiry instruction, judging by the relatively high mean scores for both groups of participants with regard to the provision of inquiry activities, as described by the essential features of inquiry-based instruction. However, compared with their students, science teachers showed a statistically significant higher mean score with regard to the provision of curriculum materials in supporting implementation of inquiry instruction and a lower mean score with regard to the provision of integrated science processes in curriculum materials. Other similar trends were also detected, with teachers reporting statistically significant higher mean scores than their students with regard to opportunities to plan investigations, ask questions during instruction and use of science process skills. Demographic variables of gender, teaching experience and subject taught showed no impact on teachers' views. Challenges and obstacles that are likely to impede inquiry-based instruction were also identified.

**Keywords:** inquiry based instruction, scientific inquiry, science curriculum, UAE

## INTRODUCTION

Inquiry-based instruction (I-BI) is a teaching and learning approach by which students are actively engaged and progressing towards becoming literate about what science is, what science looks like, how to do science and how to communicate science (NRC, 1996; AAAS, 1993). The processes of science are mental and physical skills for collecting information, organizing it in various ways and using it to make predictions, explain phenomena and solve problems (Carin, Bass, & Contant, 2005). According to Cianciolo, Flory and Atwell (2006, p. 50), "inquiry is a way of teaching and learning where students must apply the process of science." According to the National Research Council (1996, 2000), when doing inquiry, students practice several processes of science such as observing, questioning, examining resources, using tools and equipment, interpreting data, connecting results and communicating procedures and findings. Therefore, I-BI can be viewed as a type of instruction that provides students with opportunities to engage in the practices of scientists and to construct their own scientific knowledge through active learning rather than acquisition learning. According to this perspective, learning becomes "something students do, not something that is done to them" (NRC, 2000, p. 2). Inquiry-based teaching and learning approaches assume that students need to find solutions to authentic situations by refining and asking scientific questions; designing plans and conducting explanations; gathering and analyzing evidence and data; proposing interpretations and drawing explanations; and communicating procedures and findings (Linn, Clark, & Slotta, 2003; Marx et al., 2004; NRC, 1996, 2000). I-BI therefore includes a wide range of science teaching approaches such as hands-on and project-based science activities; guided discovery; experimental investigations; laboratory works; problem-solving; designed-based approaches; and conducting actual research.

However, to develop inquiry-oriented behaviors among students, science teachers must also integrate the processes of science as an integral component of inquiry. Thus, development of students' science process skills and


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**Contribution of this paper to the literature**

- The study describes perceptions of science teachers and their students of the extent of inclusion of inquiry in a reformed secondary school science curriculum.
- The study compares perceptions of science teachers and their students of actual practices of inquiry based instruction as it happens in science classrooms.
- The study categorizes the perceived challenges and obstacles that are likely to impede and hinder science teachers' implementation of inquiry-based instruction and processes of science.

reasoning abilities has become a universal goal around the world and has a special importance in science curricula. Educators regard science process skills (SPS) and reasoning as fundamental capabilities that derive and promote inquiring minds in students and thus empower students to become independent thinkers and responsible learners capable of solving today's and tomorrow's problems. Learners with such skills will be in a better position to learn meaningfully and thus acquire practical knowledge and skills needed for this fast moving and changing world.

Processes of science represent a wide range of skills including observing, measuring, classifying, inferring, identifying variables, experimenting and communicating. Generally, teaching activities that support complete or partial student-centered application and focus on exploration and experimentation are categorized as I-BI and processes of science.

## Context of the Study

The United Arab Emirates (UAE) has taken considerable reform initiatives since the beginning of the 21st century with regard to teaching science in Emirati schools. In the UAE, the Ministry of Education (MOE) has been making significant efforts to apply I-BI in the national schools. The MOE emphasizes the inclusion of inquiry-based science teaching and learning in the public school science curriculum and programs. The National Science Curriculum Framework (NSCF) declared that abilities of scientific inquiry must be part of students' learning competencies if the advocated educational reforms are to be implemented. Seven wide-ranging goals for science education are stated in the UAE (Ministry of Education, 2001). The goals draw on themes of the nature of science; processes of science; scientific inquiry; scientific knowledge; scientific literacy; scientific values, attitudes, habits of minds and dispositions; and the interactions of science, technology and society. These goals are similar to those that are recommended by the contemporary international education community (see Carin, Bass, and Contant, 2005; National Research Council (NRC), 1996). For example, goal one states that the learner should apply scientific inquiry in a way that could lead to developing science thinking skills. Goal seven is oriented towards providing the learner with scientific skills that support more advanced learning opportunities (Ministry of Education 2001, 43). Moreover, NSCF includes educational standards for all school science domains and standards for scientific inquiry that are similar to those emphasized by National Science Education Standards (NRC 1996, 2000). More recently, the MOE introduced a revised NSCF (Ministry of Education, 2014) that infuses inquiry-based pedagogy throughout national science education curricula. "The modern, technologically and scientifically advancing world requires Emirati citizens who are able to use critical, creative thinking, research, exploration, and analysis to come to reasonable conclusions about scientific inquiry" (Ministry of Education, 2014). Therefore, science inquiry activities have become central components in UAE school science textbooks and workbooks. The content of most K-12 science curricula in the UAE are said to support science teachers' use of inquiry-based instruction. Similarly, Cycles 2 and 3 textbooks and workbooks, with almost the same structure and use by students, are also said to support students' inquiry learning. These textbooks and workbooks are designed to enhance students to engage in scientific practices such asking researchable questions, plan and implement small scale projects, evaluate and analyze data collected from these projects, and communicate their findings in scientifically oriented ways. At science teacher preparation level, pre-eservice science teachers at the United Arab Emirates University (UAEU), the main national institution, are prepared to teach science through methods of inquiry that involve open, guided and structured inquiry. Brown and Melear (2006, p. 940) argue that teachers' "practices will change as a result of experiences with authentic inquiry based science methods."

However, in the context of the present study, only limited research has explored how the goals, standards and science curriculum materials promulgated by the Ministry of Education (MOE) have been implemented and used in classrooms. Globally, the literature related to science education indicates that the implementation of inquiry-based teaching and learning in science classroom practices may not be at a level that matches the efforts and emphasis provided by different educational authorities who call for consistent implementation of such instruction in the classroom (Aoki, Foster, & Ramsey, 2005). Internationally, it is said that science teachers view inquiry positively; however, little data exist to show that teachers use inquiry instruction (Kim, Tan, & Talue, 2013; Minelli, 2012; Songer, Lee, & Kam, 2002).

In the context of the UAE, it is not yet understood how science teachers perceive the provision of inquiry instruction within unified and reformed curriculum materials. Furthermore, the extent of their actual practice of inquiry instruction has also not been previously explored. Understanding how science teachers perceive the provision of inquiry materials in the curriculum and how they implement inquiry-oriented instruction could lead to the development and implementation of new policies within the MOE to promote better learning opportunities for students to learn scientific inquiry.

# PURPOSE

The purpose of this study, therefore, was to examine science students' and teachers' views of the provision and implementation of I-BI in UAE secondary school science classes. We believe that through examining science teachers' and students' perspectives about I-BI, we can identify the extent to which I-BI is provided and implemented in the recently reformed science curriculum materials and how this knowledge affects their practice of I-BI in science classes. The current study also intended to identify obstacles hindering Emirati school science teachers and their students from practicing I-BI and processes of science. Thus, the problem of the current study is to investigate the status of using I-BI in science classrooms in the UAE and to identify challenges or obstacles hindering science teachers and students from implementing such instruction. Specifically, the study seeks to achieve the following purposes:

1. Identify science students' and science teachers' perceptions of the extent of inclusion of inquiry-based instruction in the implemented curriculum;
2. Identify level of implementation of inquiry-based instruction and processes of science as perceived by science students and science teachers; and
3. Identify the perceived challenges and obstacles that are likely to impede and hinder science teachers' implementation of inquiry-based instruction and processes of science.

## Research Questions

1. How do Emirati science students and science teachers perceive the level of provision of inquiry-based instruction in curriculum materials?
2. To what extent do Emirati school science teachers and their students practice inquiry-based instruction and processes of science?
3. What are the challenges or obstacles that hinder Emirati school science teachers and their students from practicing inquiry-based instruction and processes of science?

## Theoretical Background & Previous Studies

National and international science education reform efforts call educators to move from didactic or traditional teaching methods to teaching methods that provide opportunities for all students to become engaged in meaningful, more active and higher-level learning (Martin, 2010). Inquiry-based instruction characterizes an exit from traditional or didactic science teaching in which science is seen simply as a body of facts to be transmitted from teachers to students. According to recent science education reform, the duties of the teachers in an I-BI are relatively different from those of teachers in traditional classrooms. Furthermore, science education reforms emphasize the importance of inquiry practices for K-12 students (American Association for the advancement of Science AAAS, 1989, 1993; National Research Council NRC, 1996, 2000, 2005). I-BI is gradually becoming an important theme in significant international science education reform efforts (Al-Naqbi, 2010; Australian Education Council, 1994; Osborne & Dillon, 2008). Project 2061 (AAAS, 1989) and the National Science Educational Standards NSES (NRC, 1996), which considered I-BI the foundation for the standards, defined inquiry teaching as both a pedagogical strategy and a learning goal. Inquiry teaching "refers to the activities of students in which they develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23). Project 2061 (AAAS, 1989, p. xiv), for example, defined the goal of inquiry teaching as "help[ing] people in every walk of life to deal sensibly with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty." Likewise, DeBoer (2004) explained how engaging students in scientific inquiry can serve many purposes, including the following: (a) the preparation of future scientists, (b) student motivation and (c) the development of citizens who will be autonomous and independent thinkers.

Recent studies such as those of Blanchard et al. (2008), Lederman, Lederman, and Wickman (2008) and Lewis and Lewis (2008) provide further evidence on the effectiveness of inquiry-based curriculum materials and teaching strategies. For example, Blanchard et al. (2008) compared learning improvements in middle and high school students after they are taught a forensic unit by either traditional methods or inquiry-based methods. With participation of 1,800 students and 24 teachers from seven schools, the study revealed significantly higher posttest scores favoring the students taught by inquiry teaching strategies. Based on early work of learning theorists such as Piaget, contemporary learning theories advocate the use of inquiry-based teaching and learning in science classrooms (Bruner, 1977; DeBoer, 2004, NRC, 1996, 2000). Moreover, I-BI is founded on constructivist theory, which posits that all learners incrementally develop knowledge and understanding from their experiences and that they share their knowledge through interactions with others (Brandon et al., 2009). Edelson, Gordin and Pea (1999) stated that "inquiry activities provide a valuable context for learners to acquire, clarify, and apply an understanding of science concepts" (p. 392).

## Nexus of I-BI and the Processes of Science

Most curricular around the world recognize that the processes of science in the development of learners' thinking perspectives are needed to make sense of the scientific aspects of the world. They are essential for student learning and beneficial because they are transferable thought processes. Settlage and Southerland (2007) justify the importance of teaching these processes and argue that they provide students with active learning, sense-making tools, language development and a community of learners and that they foster a natural sense of curiosity. Meador (2003) links the processes of science to inquiry learning and thinking and argues for their role in fostering inquiry behaviors and creativity. Thus, she contends that inquiry learning, creative thinking and the processes of science are intertwined, and those who use the processes of science are more likely to become better inquirers. The underlying principle of inquiry-based learning and instruction is the ability to use the processes of science. Because inquiry and the science process skills are interrelated, one is necessary for the other; they should be effectively integrated. Cain (2002) argues that science process skills are essential to doing inquiry because they are "basic to all later learning." Settlage and Southerland (2007) also link the processes of science to inquiry by saying that they are the foundation of scientific inquiry. Furthermore, NRC (2000) suggests essential features of inquiry, each of which requires use of the processes of science.

The NRC (2000, p. 29; 2012, p. 42) describes I-BI as having five "essential features" confirmed in the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013). These features are as follows: 1) Learner engages in scientifically oriented questions (Questions); 2) Learner gives priority to evidence in responding to questions through application of science processes (Evidence); 3) Learner formulates explanations from evidence (Analysis & Explain); 4) Learner connects explanations to scientific knowledge (Connect); and 5) Learner communicates and justifies explanations (Communicate). One feature, explain, appears as analysis and explain because students should analyze collected evidence to formulate their explanation of a phenomenon (NRC, 1996, 2000). Summarizing the five essential features of I-BI as Questions, Evidence, Analysis, Connect and Communicate was suggested and used by Asay and Orgill (2009).

This description entails essentially restructuring the learning resources (curriculum) and teaching processes to translate the five essential elements into a learning environment that is productive and supportive to being able to ask questions, use evidence and explanations, connect explanations to new scientific knowledge and communicate newly developed scientific explanations and evidence to others. Crawford (2007) believes that inquiry science teaching should lead to the following:

> *"appreciating the diverse ways in which scientists conduct their work; understanding the power of observations; knowledge of and ability to ask testable questions, make hypotheses; use various forms of data to search for patterns, confirm or reject hypotheses; construct and defend a model or argument; consider alternate explanations, and gain an understanding of the tentativeness of science" (p. 614).*

NRC (1996, 2000) describes a range of teaching and learning activities that could lend themselves to making classrooms inquiry oriented. The general view, however, is that engaging in teaching science as inquiry requires teachers to adapt and model scientific knowledge in a way similar to scientists and to guide students to develop and construct their own learning and personal perspectives of science. Furthermore, Kim, Tan and Talue (2013) stated "in practicing science as inquiry, it is widely established that students should be provided with opportunities to gather evidence, decide the value of the evidence, and craft coherent scientific explanations based on the available evidence" (p. 291).

The current study used these essential features of classroom inquiry described by NRC (2000, 2012) as a point of departure to ground the intended definition and focus of inquiry-based instruction and subsequently to borrow, modify and design the study instruments to answer the research questions.

## Challenges or the Obstacles of I-BI

Inquiry-based instruction presents challenges to both teachers and students. I-BI challenges teachers to do several tasks such as develop or modify content knowledge and plan for appropriate teaching and assessment techniques (Edelson, Gordin, & Pea, 1999; Marx et al., 2004). Inquiry-based learning requires students to work in a cooperative learning environment, use different thinking models and apply newly constructed science concepts in their own lives (Marx et al., 2004; Roth, 1995).

Barriers or obstacles that must be overcome for teachers to acquire an inquiry approach to teaching and the processes of science have long been discussed in the literature. Anderson (2002) grouped such barriers into three dimensions: technical, political and cultural, and summarized them as follows: The technical dimension includes limited ability to teach constructively, prior commitments (e.g., to a textbook), inadequate in-service education and challenges of assessment, group work, new teacher roles and new student roles. The political dimension includes limited in-service education (i.e., not sustained for a sufficient number of years), parental resistance, unresolved conflicts among teachers, lack of resources and differing judgments about justice and fairness. The cultural dimension—possibly the most important because beliefs and values are so central to it—includes the textbook issue, views of assessment and the "preparation ethic,", i.e., an overriding commitment to "coverage" because of a perceived need to prepare students for the next level of schooling. Gejda and LaRocco (2006) state that there are facilitators and obstacles disturbing the practice of inquiry-based teaching and learning in schools. Among the factors reported as affecting teachers' practice of I-BI are mandatory assessment, time, resources, science content and science teachers' professional development. Other reasons for not employing I-BI include limited teacher preparation; difficulty teaching; lack of support; students' immaturity; risky experiments; high cost; and difficulty tracking the progress of students (Martin, 2010). Songer, Lee and Kam (2002) investigated the barriers to technology-rich inquiry pedagogy in urban science classrooms and kinds of programs and support structures that allow these barriers to be overcome. Their study tracked classroom research on a technology-rich inquiry weather program with six urban science teachers. The teachers implemented this program in coordination with a district-wide middle school science reform. This study discovered persistent barriers such as several cases of insufficient space and materials, inadequate time, low content knowledge among teachers, large class sizes, high student and teacher mobility, limited instructional freedom and unreliable Internet connectivity.

## METHODOLOGY

The current study applied both quantitative and qualitative methods. The quantitative methods involved analyses of self-reports of students and teachers based on responses to questionnaires specifically developed to address the extent of provision of curriculum materials supporting inquiry and extent of practice of inquiry instruction in science classrooms. The self-reports of students and teachers were based on current curriculum materials taught in Cycle 2 and 3 textbooks and workbooks that reflect the current national science curriculum framework recently introduced by the Ministry of Education of UAE (Ministry of Education, 2014). The qualitative methods involved analyses of interview data collected from selected science teachers about the challenges and obstacles that may hinder the use and implementation of inquiry-based teaching strategies.

### Participants

The target population for this study was school science teachers and their students in the Northern Emirates. In total, 560 science students and science teachers participated in this study, selected using cluster sampling technique. Characteristics of students and teachers are presented in **Tables 1** and **2**.

**Table 1.** Student sample characteristics

| Variable | # | Frequency | Percent |
|---|---|---|---|
| Grade level | 9 | 31 | 6.7 |
| | 10 | 115 | 25.0 |
| | 11 | 206 | 44.8 |
| | 12 | 108 | 23.5 |
| Total | | 460 | 100 |
| Gender | Male | 202 | 43.9 |
| | Female | 258 | 56.1 |
| Total | | 460 | 100 |

**Table 2.** Teacher sample characteristics

| Variable | Category | Frequency | Percent |
|---|---|---|---|
| Gender | Male | 43 | 43 |
| | Female | 57 | 57 |
| Subject taught | Biology | 23 | 23 |
| | Chemistry | 26 | 26 |
| | General Science | 16 | 16 |
| | Physics | 30 | 30 |
| | Missing | 5 | 5 |
| Qualifications | Diploma | 6 | 6 |
| | Bachelor | 82 | 82 |
| | Master | 8 | 8 |
| | PhD | 1 | 1 |
| | Missing | 3 | 3 |
| Teaching experience | Below 5 years | 5 | 5 |
| | 5–10 years | 19 | 19 |
| | More than 10 years | 74 | 74 |
| | Missing | 2 | 2 |
| Total | | 100 | 100 |

## Instruments

A questionnaire of two versions was developed—one version for science teachers (Science Teacher Questionnaire (STQ) and one version for their students (Student Questionnaire (SQ). The purpose of these questionnaires was to collect information on the provision and extent of the implementation of I-BI in science classrooms and selected contextual variables, such as teacher gender, teaching experience and subject taught, that might have impact on such provision and implementation. The questionnaires have similar scales and items. The only difference is the wording of items to reflect the respondents' use of inquiry instruction. The questionnaire items were originally written in English and then translated into Arabic. Each version of the questionnaire asks respondents to respond in two ways— one for assessing students' and teachers' perceptions about the provision of curriculum materials in supporting inquiry instruction and another for assessing students' and teachers' perceptions of the extent of the science teacher's practice of inquiry-based instruction. Although there are many I-BI indicators identified in the literature (Brandon et al., 2009), all 47 items comprising the 2 versions of the questionnaires were developed using a framework based on fundamental inquiry abilities developed by Al-Naqbi (2010). This framework is closely related to the five essential features associated with inquiry instruction identified by NRC (1996, 2000) as applicable in grades 9–12:

- Identify questions and concepts that guide scientific investigations (Questions).
- Design and conduct scientific investigations (Evidence).
- Formulate and revise scientific explanations and models using logic and evidence (Analysis & Explain).
- Recognize and analyze alternative explanations and models (Connect).
- Communicate and defend a scientific argument (Communicate). (NRC, 2000, p. 19)

The framework grouped the fundamental inquiry abilities into five essential features of inquiry, which are questioning (Questions), planning and implementing (Evidence), formulating and revising scientific explanations (Analysis & Explain), concluding (Connect) and communicating (Communicate). Two sub-features associated with planning and implementing essential feature of inquiry, namely, the application of basic and integrated science process skills in inquiry contexts, were also used to complement the framework.

To understand the perceived support of curriculum materials for inquiry instruction, students and teachers were required to identify the level of support provided by these curriculum materials from 1, indicating no or very little provision, to 5, indicating a very high level of provision. Similarly, to understand the perceived extent of practice of I-BI by participating science teachers, students and teachers were asked about the frequency with which teachers used a range of inquiry-related practices identified in this study as essential features of inquiry, whether such practices were used very often, often, sometimes, rarely or never.

To establish content, face and construct validity of the two questionnaires, all items were reviewed by three science educators and two science teachers. These experts revised some of these items and then approved them as addressing the targeted aspect of inquiry instruction as described by the essential inquiry features outlined above. To further ensure content validity, the Arabic versions of the questionnaires were translated back to English and

**Table 3.** Reliability coefficients of the questionnaires

| Scale | # items | Student version | | Teacher version | |
|---|---|---|---|---|---|
| | | Version 1 | Version 2 | Version 1 | Version 2 |
| Entire questionnaire | 47 | 0.97 | 0.95 | 0.94 | 0.93 |
| Questions | 5 | 0.77 | 0.75 | 0.84 | 0.71 |
| Evidence | 5 | 0.81 | 0.82 | 0.85 | 0.85 |
| Basic science processes | 9 | 0.91 | 0.90 | 0.93 | 0.91 |
| Integrated science processes | 7 | 0.89 | 0.88 | 0.91 | 0.91 |
| Analysis & Explain | 8 | 0.91 | 0.89 | 0.93 | 0.92 |
| Connect | 5 | 0.87 | 0.84 | 0.90 | 0.87 |
| Communicate | 8 | 0.90 | 0.88 | 0.93 | 0.92 |

compared with the original English versions for accuracy of content. **Table 3** displays the total number of items in each version for the whole questionnaire in addition to the items comprising each feature of inquiry.

To establish reliability, Cronbach's α coefficients were obtained for the student and teacher versions and for each of the essential inquiry features used here as distinct scales. The Cronbach's α coefficients for these scales, presented in **Table 3**, are relatively high and acceptable, indicating a reliable internal consistency of the two versions of the questionnaire.

## Interview Protocols

A sample of 45 science teachers who responded to the teacher questionnaire (STQ) were interviewed. The interview focused on finding in-depth information about science teachers' and their students' knowledge, practice and barriers hindering science teachers and their students from practicing I-BI and processes of science. According to Axinn and Pearce (2006), interviews can offer a more in-depth understanding of the various issues associated with the performance of reform teaching, and they are more flexible and allow the interviewees to raise new issues and guide the interview towards the most relevant aspects.

## Data Analysis

Data were originally collected from 481 students and 112 science teachers. Data cleaning resulted in the elimination of some incomplete responses. As such, data analysis is based on a sample of only 460 students and 100 science teachers. Data analysis started with descriptive statistics for each scale and for the demographic variables collected by the questionnaires. The second analysis consisted of comparisons of main scores for each scale between pairs of demographic variables collected by the questionnaire such as gender, teaching experience, and subject taught, in addition to impact of prior knowledge of inquiry instruction and professional development activities. In contrast, interview data were analyzed thematically to identify themes and norms in interviewees' responses.

# FINDINGS

Data collected by the questionnaires were analyzed descriptively to answer the first and second research questions: What level of support for I-BI instruction do science students and science teachers perceive from curriculum materials? To what extent do school science teachers and their students practice I-BI and processes of science? Students and teachers responded to 47 questionnaire items across 5 scales and 2 sub-scales. The mean for each scale for teachers and students concerning curriculum materials' provision and science teachers' actual practice by of inquiry was calculated based on a 5-level response ranging from 1, indicating no or very little provision or actual practice, to 5, indicating a high level of provision and actual practice. Related to the perceptions of provision and actual practice by science teachers of I-BI, the present study also assessed the impact of demographic variables such as gender, teaching experience and subject taught on science teachers' perceptions of the I-BI. The assessment of the impact of demographic variables covers all levels of provision in the curriculum materials and the actual implementation in classrooms to provide comprehensive views about these variables.

## Provision of I-BI in Curriculum Materials

The science teachers participating in this study showed higher mean scores than the students across all scales, suggesting that the teachers perceived a higher level of inquiry instruction provided in the curriculum materials of the MOE.

As shown in **Table 4**, both students and teachers believed that the curriculum materials lend themselves to supporting inquiry instruction, judging by the relatively high mean scores for both groups. Science teachers showed

**Table 4.** Perceived provision of I-BI in curriculum materials by science teachers and their students

| Scale | Students | | | Teachers | | | t-value | $r^2$ |
|---|---|---|---|---|---|---|---|---|
| | M | SD | Rank | M | SD | Rank | | |
| Questions | 3.26 | 0.88 | 3 | 3.54 | 0.72 | 6 | 2.99** | 0.06 |
| Evidence | 3.26 | 0.96 | 3 | 3.64 | 0.77 | 3 | 4.07*** | 0.10 |
| Basic science processes | 3.29 | 0.97 | 2 | 3.55 | 0.76 | 5 | 2.77** | 0.04 |
| Integrated science processes | 3.25 | 1.02 | 4 | 3.43 | 0.79 | 7 | 1.76 | 0.01 |
| Analysis & Explain | 3.36 | 0.92 | 1 | 3.92 | 0.65 | 1 | 4.01*** | 0.09 |
| Connect | 3.16 | 1.04 | 5 | 3.56 | 0.78 | 4 | 3.73*** | 0.08 |
| Communicate | 3.14 | 1.01 | 6 | 3.66 | 0.77 | 2 | 1.78* | 0.01 |

* P ≤ 0.05; ** P ≤ 0.01; *** P ≤ 0.001

**Table 5.** Science teacher perceptions of provision of I-BI in curriculum materials by gender

| Scale | Male | | Female | | t-value |
|---|---|---|---|---|---|
| | M | SD | M | SD | |
| Questions | 3.46 | 0.58 | 3.58 | 0.82 | 0.82 |
| Evidence | 3.49 | 0.73 | 3.78 | 0.78 | 0.51 |
| Basic science processes | 3.48 | 0.69 | 3.61 | 0.81 | 0.78 |
| Integrated science processes | 3.47 | 0.77 | 3.39 | 0.82 | 0.51 |
| Analysis & Explain | 3.49 | 0.73 | 3.76 | 0.78 | 1.78 |
| Connect | 3.43 | 0.75 | 3.59 | 0.79 | 0.95 |
| Communicate | 3.23 | 0.92 | 3.44 | 0.82 | 1.12 |

**Table 6.** Science teacher perceptions of provision of I-BI in curriculum materials by teaching experience

| Scale | Below 5 years | | 5 – 10 years | | More than10 years | | F |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | |
| Questions | 3.80 | 0.57 | 3.41 | 0.88 | 3.53 | 0.69 | 0.491 |
| Evidence | 3.75 | 0.19 | 3.56 | 0.90 | 3.65 | 0.77 | 0.129 |
| Basic science processes | 3.75 | 0.57 | 3.49 | 0.87 | 3.53 | 0.74 | 0.165 |
| Integrated science processes | 3.71 | 0.76 | 3.21 | 0.68 | 3.43 | 0.82 | 0.813 |
| Analysis & Explain | 3.75 | 0.19 | 3.56 | 0.90 | 3.65 | 0.77 | 0.129 |
| Connect | 3.68 | 0.54 | 3.41 | 0.77 | 3.54 | 0.81 | 0.262 |
| Communicate | 3.50 | 0.54 | 3.20 | 0.99 | 3.36 | 0.87 | 0.267 |

the highest perception of curriculum materials' support of inquiry instruction (M = 3.92) and the lowest perception of integrated science processes provided in the curriculum materials (M = 3.43). The students agreed with the teachers in perceiving high support of curriculum materials for the implementation of inquiry instruction (M = 3.36). However, the students believed that the curriculum materials provided less support for sharing and exchanging inquiry activities in classrooms (M = 3.14).

To assess whether there were statistically significant differences between the perceptions of students and teachers, t-test was conducted. As shown in **Table 4**, statistically significant views emerged, with teachers showing significantly higher perception scores across all scales except that for the support of curriculum materials in the development of integrated science processes. For all variables except the provision of planning and implementing activities, all calculated effect sizes were found to be relatively small.

The impact of teacher gender, teaching experience and subject taught on teachers' perceptions of I-BI in the curriculum was assessed by computing the mean score for each scale and compared using a t-test and analysis of variance (ANOVA). With regard to the impact of gender, the results showed that there were no statistically significant differences between male and female teachers (**Table 5**), suggesting that teacher gender has no impact on the perception of I-BI in the curriculum materials.

There was also no impact of teaching experience on the perceptions of the provision of inquiry instruction in the curriculum materials (**Table 6**). Novice, moderately experienced and highly experienced science teachers perceived the provision of inquiry instruction in the curriculum materials in a similar manner, as no statistically significant differences were found.

**Table 7** shows the analysis of the impact of the subject taught on the science teachers' perceptions of I-BI provided in the curriculum materials. The results indicated that there was no impact of subject taught on science teachers' perceptions, judging by the statistically non-significant differences between the mean scores of science teachers' perceptions. All science teachers, irrespective of the subject they taught, showed relatively similar and high perceptions regarding the opportunities provided by the curriculum materials.

**Table 7.** Science teacher perceptions of provision of I-BI in curriculum materials by subject taught

| Scale | Biology | | Chemistry | | Physics | | General science | | F |
|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD | |
| Questions | 3.17 | 0.81 | 3.64 | 0.68 | 3.70 | 0.66 | 3.66 | 0.67 | 2.547 |
| Evidence | 3.44 | 0.83 | 3.76 | 0.61 | 3.76 | 0.73 | 3.81 | 0.66 | 1.100 |
| Basic science processes | 3.62 | 0.78 | 3.52 | 0.84 | 3.60 | 0.63 | 3.67 | 0.66 | 0.126 |
| Integrated science processes | 3.27 | 0.71 | 3.42 | 0.93 | 3.62 | 0.82 | 3.42 | 0.63 | 0.723 |
| Analysis & Explain | 3.44 | 0.84 | 3.76 | 0.61 | 3.75 | 0.74 | 3.81 | 0.66 | 1.100 |
| Connect | 3.46 | 0.88 | 3.59 | 0.79 | 3.65 | 0.64 | 3.44 | 0.86 | 0.360 |
| Communicate | 3.36 | 0.96 | 3.51 | 0.80 | 3.41 | 0.81 | 3.31 | 0.79 | 0.188 |

**Table 8.** Perceived level of actual practice of I-BI by science teachers and their students

| Scale | Students | | | Teachers | | | t-value | $r^2$ |
|---|---|---|---|---|---|---|---|---|
| | M | SD | Rank | M | SD | Rank | | |
| Questions | 3.38 | 0.84 | 3 | 3.86 | 0.55 | 2 | 6.69*** | 0.17 |
| Evidence | 3.35 | 0.90 | 5 | 3.92 | 0.65 | 1 | 5.66*** | 0.21 |
| Basic science processes | 3.49 | 0.94 | 1 | 3.82 | 0.65 | 3 | 3.86*** | 0.07 |
| Integrated science processes | 3.47 | 0.94 | 2 | 3.71 | 0.75 | 5 | 2.54* | 0.04 |
| Analysis & Explain | 3.24 | 0.95 | 6 | 3.59 | 0.70 | 7 | 4.02*** | 0.09 |
| Connect | 3.36 | 0.96 | 4 | 3.80 | 0.69 | 4 | 5.10*** | 0.12 |
| Communicate | 3.38 | 0.93 | 3 | 3.63 | 0.76 | 6 | 2.56* | 0.04 |

* P ≤ 0.05; *** P ≤ 0.001

## Level of Practice of I-BI in Science Classrooms

To investigate the second research question concerning the level of practice of I-BI and processes of science in actual science classes by science students and science teachers, data from the second versions of the student and teacher questionnaires were analyzed. The second versions, which also consisted of 47 items depicting 5 scales and 2 sub-scales similar to the first versions, asked respondents to identify the level of actual practice of behaviors and features associated with inquiry instruction. The mean for each scale for teachers and students was calculated based on a 5-level response ranging from 1, indicating that the behavior/feature never occurred, to 5, indicating that the behavior/feature occurred very often.

**Table 8** shows students' and teachers' perceptions of the extent of teachers' actual use of I-BI activities. Trends depicted in **Table 4** resemble those shown for the perceptions of the provision of I-BI in the curriculum materials, with teachers reporting higher mean scores for the occurrence of these inquiry features during their teaching. Providing students with opportunities to plan investigations (M = 3.92), to engage in asking questions during instruction (M = 3.86) and to frequently use science process skills (M = 3.82) are the scales that received the highest mean sores by teachers. In contrast, frequent use of basic science processes (M = 3.49), of integrated science processes (M = 3.47) and opportunities to ask questions and discuss investigation (M 3.38) are the scales that received the highest mean scores of students.

To examine whether there were statistically significant differences between the perceptions of students and teachers with regard to the actual occurrence of I-BI in science classrooms, t-test was conducted. As shown in **Table 8**, statistically significant differences did emerge, with teachers showing significantly higher perception scores across all scales. Calculated effect sizes were found to be either moderate or large for activities associated with opportunities to ask questions, planning, implementing and connecting, and effect sizes ranged between 0.09 and 0.21. The rest of the scales showed small effect sizes ranging between 0.04 and 0.07.

The impact of teacher gender, teaching experience and subject taught on teachers' perceptions of actual practice of I-BI in their science classrooms was assessed by computing the mean score for each scale and compared using t-test and analysis of variance (ANOVA). With regard to the impact of gender, the results showed that there were no statistically significant differences between male and female teachers in all scales except the perceived actual practice of opportunities of planning (evidence) (**Table 9**), suggesting that teacher gender has no impact on the perception of actual practice of I-BI in science classrooms.

**Table 9.** Science teacher perceptions of actual implementation of I-BI in science classrooms by gender

| Scale | Male | | Female | | t-value |
|---|---|---|---|---|---|
| | M | SD | M | SD | |
| Questions | 3.76 | 0.48 | 3.95 | 0.58 | 1.672 |
| Evidence | 3.76 | 0.61 | 4.04 | 0.66 | 2.083* |
| Basic science processes | 3.73 | 0.53 | 3.89 | 0.73 | 1.150 |
| Integrated science processes | 3.66 | 0.69 | 3.76 | 0.81 | 0.639 |
| Analysis & Explain | 3.53 | 0.55 | 3.65 | o.79 | 0.771 |
| Connect | 3.73 | 0.57 | 3.86 | 0.77 | 0.935 |
| Communicate | 3.49 | 0.79 | 3.74 | 0.74 | 1.538 |

* $P \leq 0.05$

**Table 10.** Science teacher perceptions of provision of I-BI in curriculum materials by teaching experience

| Scale | Below 5 years | | 5 – 10 years | | More than 10 years | | F |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | |
| Questions | 3.80 | 0.63 | 3.98 | 0.55 | 3.83 | 0.55 | 0.535 |
| Evidence | 3.60 | 0.60 | 4.02 | 0.70 | 3.91 | 0.65 | 0.572 |
| Basic science processes | 4.09 | 0.72 | 4.00 | 0.74 | 3.81 | 0.66 | 1.580 |
| Integrated science processes | 4.02 | 0.67 | 3.69 | 0.92 | 3.68 | 0.74 | 0.483 |
| Analysis & Explain | 2.96 | 0.85 | 3.76 | 0.66 | 3.58 | 0.70 | 1.733 |
| Connect | 3.75 | 0.68 | 3.97 | 0.77 | 3.77 | 0.68 | 0.659 |
| Communicate | 3.87 | 0.70 | 3.66 | 0.79 | 3.63 | 0.77 | 0.228 |

**Table 11.** Science teacher perceptions of provision of I-BI in curriculum materials by subject taught

| Scale | Biology | | Chemistry | | Physics | | General science | | F |
|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD | |
| Questions | 3.76 | 0.55 | 3.95 | 0.55 | 3.79 | 0.54 | 3.99 | 0.56 | 0.867 |
| Evidence | 3.96 | 0.63 | 3.95 | 0.68 | 3.72 | 0.64 | 4.02 | 0.61 | 1.035 |
| Basic science processes | 3.97 | 0.63 | 3.76 | 0.82 | 3.73 | 0.62 | 3.94 | 0.52 | 0.711 |
| Integrated science processes | 3.82 | 0.62 | 3.64 | 0.97 | 3.78 | 0.71 | 3.63 | 0.67 | 0.317 |
| Analysis & Explain | 3.57 | 0.63 | 3.63 | 0.82 | 3.54 | 0.70 | 3.57 | 0.76 | 0.061 |
| Connect | 3.88 | 0.58 | 3.87 | 0.77 | 3.71 | 0.72 | 3.70 | 0.69 | 0.445 |
| Communicate | 3.68 | 0.77 | 3.75 | 0.80 | 3.45 | 0.76 | 3.60 | 0.77 | 0.686 |

Female science teachers seem to be more concerned than male science teachers that opportunities be provided for students to plan inquiry-based activities. Previous studies suggested that female teachers tend to embrace their students' personal experiences (Robin & Harris, 1998) and therefore provide them with more opportunities to plan and implement their own activities.

Furthermore, Zhou and Xu (2007) stated that female teachers tend to be less concerned with classroom control and prefer the active involvement of learners. In contrast, Park (1996) argued that female teachers prefer a student-centered approach to instruction more than their male counterparts do. Similarly, the findings of this study may be interpreted to mean that female science teachers of the present study tended to prefer student involvement in planning classroom activities and therefore encouraged student participation and activities developed by students.

There was also no impact of teaching experience on the perceptions of actual implementation of inquiry instruction in science classrooms (**Table 10**). Novice, moderately experienced and highly experienced science teachers all perceived the inquiry-oriented instruction implemented by science teachers in a similar manner, as no statistically significant differences were found.

**Table 11** shows the analysis of the impact of the subject taught by science teachers on their perceptions of the actual practice of I-BI in their classrooms. The results indicated that there was no impact of subject taught on science teachers' perceptions, judging by the statistically non-significant differences between the mean scores of science teachers' perceptions in all scales. All science teachers, irrespective of the subject they taught, showed relatively similar and high perceptions regarding their actual practice of inquiry-oriented science instruction.

## Perceived Challenges / Obstacles

Key challenges were revealed in the analyses of data collected from the structured interviews, conducted with 45 science teachers, to answer the third research question, namely, what are the challenges or the obstacles that hinder Emirati school science teachers and their students from practicing inquiry-based instruction and processes

**Table 12.** Challenges/Obstacles identified by science teachers

| Challenges/Obstacles | N | % |
|---|---|---|
| The need to cover the prescheduled content | 43 | 95.5 |
| The low level of learning motivation of students | 40 | 88.8 |
| The maturity level of students | 40 | 88.8 |
| The availability of instructional time | 39 | 86.6 |
| The teachers' limited knowledge and skills related to inquiry instruction | 36 | 80.0 |
| Shortage of inquiry related instructional resources | 35 | 77.7 |
| The suitability of curriculum content/topics to inquiry instruction | 35 | 77.7 |

of science? Science teachers were to identify the most common challenges or obstacles that hinder them and their students from practicing I-BI. **Table 12** shows the seven most common obstacles identified.

The data collected from the interviews confirm that the most common challenges were prescheduled content, learning motivation of students, maturity level of students, availability of instructional time, teachers' limited knowledge and skills, inquiry-related instructional resources and suitability of curriculum content/topics to inquiry instruction. As presented in **Table 12**, 95.5% of the teachers believed that the need to cover the prescheduled content was the greatest hindrance to practicing I-BI, and the students' low learning motivation and maturity level came second with 88.8% each. The prescheduled time may also have contributed to availability of instructional time, as 86.6% of the interviewed sample of science teachers noted this as a challenge. Furthermore, 77.7% of the interviewed teachers suggested that they have limited knowledge and skills related to inquiry instruction and how to implement I-BI.

## DISCUSSION

In this study, we drew on the conceptualization of inquiry-oriented instruction described by the NRC (1996, 2000) to develop a framework to explore the provision inquiry practices in the curriculum materials and the extent of actual practice of inquiry-oriented instruction in science classrooms. We addressed the issue of provision of inquiry instruction in curriculum materials because of the unique nature of our context. Students in our context study a centrally prescribed curriculum, in which teachers have to cover all materials and tailor them to their students. Therefore, the provision of inquiry opportunities can be considered as important as the actual teaching itself. Curriculum materials that encourage inquisitive minds through question posing, data collection, explanation and interpretation of collected evidence are considered to be the prerequisites of inquiry-oriented instruction. Students therefore need to be provided with opportunities to plan and implement investigations and test their posed questions to understand why it is necessary to investigate systematically as scientists do.

According to the NRC view, an important dimension in learning science through and as inquiry is providing students with opportunities and resources to engage with day-to-day situations, ask questions, collect observations, use logic and critical thinking to explain evidence and connect the evidence to reality. Thus, in analyzing the extent of I-BI provided in the curriculum materials, it is logically valid to ask how these curriculum materials support such learning and to what extent do science teachers actually practice the inquiry-oriented approach in their classrooms? The findings revealed in this study suggest that both students and teachers perceived a reasonable provision of inquiry-related activities in the curriculum materials, judging by the high mean scores. The statistically significant differences between student and teacher perceptions, however, may indicate that teachers are more inclined than students are to view the provision of inquiry-related activities in the curriculum materials positively. These findings confirm the orientation of the reformed centralized curriculum of the MOE that places greater emphasis on scientific inquiry as a national goal that must become part of students' learning competencies. The findings also support the contention that curriculum materials should provide opportunities for all students to become engaged in meaningful, more active and higher-level learning (Martin, 2010). These findings show that curriculum materials have started to place more emphasis on opportunities to be provided to students to realize and learn about scientific inquiry (NGSS, 2013, Lucero, Valcke, and Schellens, 2013). In fact, recent development in international science curricular reform emphasizes interdisciplinary practices and integration of core ideas and skills across disciplines. For example, the NGSS clearly demonstrate this emphasis in the suggested three domains (science and engineering practices, disciplinary core ideas, and crosscutting concepts). However, the findings reported here contradict those of Al-Naqbi (2010), who investigated workbooks of grades 5 and 6 regarding the extent to which they promote I-BI using similar framework and content analysis. His findings suggested that although the activities prescribed in the curriculum materials supported some aspects of inquiry learning, some activities did not provide context to facilitate formulating questions, planning investigations or communicating investigations (Al-Naqbi, 2010).

The significantly different perceptions of science teachers and students participating in this study of the provision of inquiry-oriented instruction in the curriculum point to two different perspectives. First, science teachers may have different conceptions of what is meant by inquiry-oriented instruction (Anderson, 2002). Previous research findings suggested that science teachers may see science content (curriculum materials) as an avenue of participation in scientific practice (Meyer, 2014) and therefore value any curriculum activity as related to inquiry-oriented practice more highly than their students. Furthermore, science teachers' views about the provision of inquiry-oriented instruction in curriculum materials are likely to influence how they practice inquiry instruction in terms of planning and implementation of learning experiences (Crawford, 2007). In fact, previous research findings have shown that positive views about I-BI such as those expressed in the present study are essential to influence teachers' intention to use inquiry in their classrooms (Choi and Ramsey, 2009). Teachers with positive views about inquiry-based curriculum materials are more likely to actively translate these curriculum materials into pedagogically engaging activities and thereby provide students with more opportunities to explore, observe, pose questions, collect data, explain evidence and connect evidence to specific scientific knowledge.

The other perspective is related to social desirability (Lakin and Wallace, 2015) on the part of the science teachers who responded to the questionnaire. Lakin and Wallace explained social desirability as the "desire to impress others favorably" (p. 143) by exhibiting responses that are more likely to be congruent with public expectations. As such, the consistently higher views of provision of I-BI in curriculum materials might be explained as socially desirable responses following curriculum expectations and the desire of the curriculum developers.

How much impact do the demographic variables of gender, teaching experience and subject taught have on science teachers' views about the provision of inquiry-oriented instruction in curriculum materials? With the exception of level of planning of inquiry activities among female science teachers, the findings suggest that these variables did not impact teachers' views, as no statistically significant differences were found between the views of science teachers based on gender, teaching experience or subject taught. The findings of Haney et al. (1996), Zhou and Xu (2007) and Marshall et al. (2009) suggested that teachers' gender, teaching experience and subject taught impact their perceptions of I-BI, as female teachers were found likely to place more value on inquiry-based instruction. The findings of the present study do not support the findings of Haney et al. (1996) and Zhou and Xu (2007), as male and female teachers have shown similar views with regard to the provision of I-BI in curriculum materials. However, the findings of the present study did not support Marshall et al. (2009), where the subject taught significantly predicted the time spent in inquiry-based instruction. Marshall et al. (2009) interpreted the impact of teacher subject to be due to variation in the content knowledge of the sample, where certain topics may lend themselves to I-BI more than others do. In the present study, however, science teachers taught the same prescribed textbooks and topics, and this may reduce variations in the way they translate the curriculum into learning activities.

The findings of this study confirmed the findings of previous studies that identified obstacles to science teachers' practices of I-BI (see for example, Anderson, 2002; Gejda & LaRocco, 2006; Songer, Lee, & Kam, 2002). The most common factor was time. Science teachers believed that they had to cover the prescheduled content to prepare their students for mandated testing and assessment. It seems that science teachers still concentrated on delivering the prescribed content and preparing students for assessment procedures. International science education reform documents such as that of (NRC, 1996, 2000, 2005) stated that time is an important facilitator in carrying out I-BI, particularly when students engage in application of science processes that require more time and efforts to collect evidences, analyze them, and communicate their findings to wider communities. As suggested by Goodrun, Hackling, and Rennie (2000), science processes are key feature in the practice of inquiry that allows students to develop their knowledge and scientific arguments. Other challenges noted by science teachers were the students' low levels of learning motivation and maturity. Moreover, science teachers believed that their knowledge and skills related to inquiry instruction was limited. This leads us to recommend that in-service science teachers participate in a specific professional development program about inquiry teaching and learning. This program should provide them with a wide range of activities and practices to support them in implementing I-BI.

## Implications of Findings

This study has explored secondary school science teacher and student perceptions of the provision and actual practices of inquiry in the secondary school science curriculum. The findings reported in this study have a number of implications. First, the different perceptions between students and their teachers with regard to the provision and actual practices of inquiry need to be reconciled. This requires more efforts on the part of the science teachers to make students realize inquiry as a learning approach by contextualizing classroom activities to reflect relevance and fruitfulness and motivating students to study and learn through inquiry-based activities. Successful practice of I-BI requires students to work with activities and learning experiences in different contexts and cognitive levels. Students may need to engage in indoor and outdoor learning activities that require instructional resources. Therefore, a wide range of materials, instruments and learning tools should be available for students. Related to this point is the rescheduling of the instructional time of science teaching, one of the challenges identified by science teachers. Curriculum developers should consider rescheduling to provide adequate instructional time for science teachers to practice I-BI and other student-centered instructional activities.

The findings also suggest that science teachers should be provided with professional development training activities to improve their personal knowledge and skills related to inquiry teaching. These may include professional development training programs targeting inquiry skills that are particularly relevant to the findings reported in this study. Curriculum revision to reduce the conceptual load may benefit students and make the instruction more focused. This may lead students to be more motivated, thereby reducing the challenges identified by science teachers as hindering the implementation of inquiry-based learning.

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# APPENDIX I

## Science Teacher Perceptions of Inquiry-Based Instruction Questionnaire

### Sample Items

To what extent do you think the curriculum allows students to engage in the following statements? How often do students engage in applying these statements in classroom?

| Level of provision in the curriculum | | | | | | Statement | Level of Practice | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Highly Provided | Provided | Provided to some extent | Rarely Provided | Not Provided | # | | Very Often | Often | Sometimes | Rarely | Never |
| | | | | | 3 | Ask questions based on observations | | | | | |
| | | | | | 6 | Plan/design a simple investigation/experiment | | | | | |
| | | | | | 9 | Use simple skills to collect & analyze data | | | | | |
| | | | | | 14 | Collect evidence | | | | | |
| | | | | | 15 | Provide explanation for the evidence | | | | | |
| | | | | | 20 | Connect findings with previous scientific knowledge | | | | | |
| | | | | | 25 | Report out data/results of group work to whole class | | | | | |
| | | | | | 32 | Prepare students to observe scientific phenomena related to their curriculum. | | | | | |
| | | | | | 36 | Give students opportunities to identify important scientific problems. | | | | | |
| | | | | | 39 | Encourage students to use effective communication skills, i.e. to draw maps, charts, symbols, graphs and diagrams to communicate learned information. | | | | | |

# APPENDIX II

## Science Student Perception of Inquiry-Based Instruction Questionnaire

### Sample Items

To what extent do you think the curriculum allows you as a student to engage in the following statements, and how often do you as a student engage in applying these statements in classroom?

| Level of provision in the curriculum | | | | | | | Level of Practice | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Highly Provided | Provided | Provided to some extent | Rarely Provided | Not Provided | | Statement | Very Often | Often | Sometimes | Rarely | Never |
| | | | | | 3 | Ask questions based on observations | | | | | |
| | | | | | 6 | Plan/design a simple investigation/experiment | | | | | |
| | | | | | 9 | Use simple skills to collect & analyze data | | | | | |
| | | | | | 14 | Collect evidence | | | | | |
| | | | | | 15 | Provide explanation for the evidence | | | | | |
| | | | | | 20 | Connect findings with previous scientific knowledge | | | | | |
| | | | | | 25 | Report out data/results of group work to whole class | | | | | |
| | | | | | 32 | Teacher prepares students to observe scientific phenomena related to their curriculum. | | | | | |
| | | | | | 36 | Teacher gives students opportunities to identify important scientific problems. | | | | | |
| | | | | | 39 | Teacher encourages students to use effective communication skills, i.e. to draw maps, charts, symbols, graphs and diagrams to communicate learned information. | | | | | |

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