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Analysis of Cycle 2 Science Textbooks Representation of Scientific Literacy and Reliability Level

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ANALYSIS OF CYCLE 2 SCIENCE TEXTBOOKS REPRESENTATION OF SCIENTIFIC LITERACY AND READABILITY LEVEL

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The framework used to examine the aspects of the Scientific Literacy presents science as (a) a body of knowledge, (b) a way of investigating, (c) a way of thinking, and (d) an interaction with technology and society (STS). The readability of the science textbooks was determined by using two instruments namely the Flesch-Kincaid Grade Level Readability Formula and the Fry Graph. The actual reading ability of the involved student was determined by the Cloze Test.

The findings showed that while high percentages of content coverage were based on a theme of science as a body of knowledge across all grades, there was a tendency of less representation of this theme as we move up the grades (from grade 6 to grade 9). However, the overall results suggested that the representation of the themes were not really balanced. Science as a way of knowing, as investigative activities, and as interaction with science, technology was all neglected in these textbooks. Findings related to the readability analyses suggested that there was a mismatch between textbooks intended reading levels and the student actual reading levels, indicating that all the textbooks are somewhat complex and far above the reading ability levels of the intended readers. Grades 6, 7, and 8 textbooks showed the highest mismatch as high as two grades level above the actual intended reading level. The findings also indicated that Grade 9 textbook was slightly difficult for the students by one age level higher.

These findings were discussed in the context of science education research with particular emphasis on how science teachers may use textbooks to lessen their impact in regard to views about Scientific Literacy and readability characteristics.

Specific recommendations were that authors and teachers had the responsibility to balance the content in terms of the themes describing the Scientific

Literacy and improve the level of readability of science textbooks. Furthermore, science teachers can play a major role in improving students' reading abilities by using different teaching strategies.

Based on the findings that emerged from the present study, specific suggestions for future research were presented. Studies related to how science teachers conceptualize Scientific Literacy might produce findings that may encounter the imbalance representation of Scientific Literacy themes in these textbooks. Studies on how teachers can explicitly highlight the nexus among science, technology and society would lead to, a realization that science is more than simply the scientific knowledge. Furthermore, investigate the influence of textual difficulty in science textbooks on the students of different levels of reading achievement. Examine the differences of reading ability with regard to students' gender across the same topics of the science textbooks.

Keywords: Scientific Literacy, Readability, Student reading level, Readability assessment, UAE Science textbooks, Cycle 2.

Title and Abstract (in Arabic)

تحليل مستوى تمثيل المعرفة العلمية وإقرائية كتب العلوم للحلقة الثانية

الملخص

لأكثر من نصف قرن، لعبت الكتب الدراسية دورًا حاسمًا في أنشطة التعليم والتعلم، كما تعد الأدوات التعليمية الأولية في الفصول الدراسة العالمية، والتي لها تأثير أكبر في كيفية توصيل المعرفة وإبلاغها. ومع تطور المجتمع، فإن غالبية المعلمين يستخدمون الكتب الدراسة لتوجيه العملية التعليمية. ومن ناحية أخرى، مقروئية الكتب لها أهمية بداية لكل من المهتمين في مجال التعليم ومؤلفي الكتب الدراسية. ويعد العثور على صلة مناسبة بين قدرة الطلاب على القراءة وصعوبة النص مهمة صعبة ومهمة للمعلمين.

وتتمحور هذه الدراسة حول كيفية تقييم وتحليل المحتوى العلمي لكتب العلوم للحلقة الثانية في مدارس مجلس أبوظبي للتعليم. وكذا تهدف إلى التعرف على جوانب المعرفة العلمية التي أكدت عليها كتب العلوم المستخدمة في الصفوف (6 - 9) وتحديد مستوى مقروئية هذه الكتب العلمية.

وقد تمثلت الدراسة نوعين من الفيلات والإجراءات المتبعة لتطبيق الفيلات. الفيلة الأولى: هي الكتاب العلوم (Science Focus) المقرر لطلبة الصفوف (6،7،8،9)، (نسخة الطالب)، الطبعة الثانية المؤلف بواسطة Whalley, Phillips, Monckton, Roberson, Mayers, Brown, and Naville (2009). وأما العينة الثانية: تمثل عدد الطلاب المشاركين في الدراسة (200 طالباً) من مدرستين حكوميتين للحلقة الثانية تغطي الصفوف (9 - 6) خلال العام الدراسي 2013 - 2014. وقد تم اختيار الكتب الدراسية لما تتضمنه من محتوى وتحليل مستوى مقروئيتها وتم اختيار الطلاب لتحديد القدرة على القراءة الفعلية.

والإطار المستخدم لفحص جوانب المعرفة العلمية يركز على وصف المعرفة العلمية على أنها (أ) مجموعة من المعارف، (ب) وسيلة للتحقق، (ج) طريقة التفكير، و (د) التفاعل مع التكنولوجيا والمجتمع (STS). وذلك لتحديد مقروئية كتب العلوم باستخدام أداتين هما: اختبار (Flesch-Kincaid Grade Level Readability Formula) لمستوى المقروئية والرسم البياني (Fry Graph). كما تم أيضاً تحديد القدرة على القراءة الفعلية للطلبة المشاركين في الدراسة من خلال اختبار كلوز (Cloze Test).

وأظهرت النتائج أن المحتوى يعطي صورة عالية متماثلة في "العلوم كمجموعة من المعرفة" لجميع المراحل، ويميل هذا الاتجاه للتناقص كلما انتقلنا لمراحل الصفوف العليا (من الصف 6 الى الصف 9). ومع ذلك تشير النتائج الإجمالية أن تمثيل الموضوع لم يكن متوازنا. فالعلوم كوسيلة للمعرفة، كوسيلة للتحقيق، والتفاعل مع العلوم والتكنولوجيا قد أهمل في هذه الكتب. وتشير النتائج المتعلقة بمقروئية الكتب أن هناك عدم تطابق بين مستويات قراءة الكتب الدراسية و مستويات القراءة الفعلية للطالب. كما تشير إلى أن جميع الكتب المدرسية معقدة بعض الشيء، وأعلى بكثير من مستويات القدرة على القراءة من قبل الفئة المستهدفين وأشارت النتائج أيضا إلى أن الكتب الدراسية للصفوف (6 -7 -8) أظهرت أعلى عدم تطابق يصل إلى مرحلتين دراسيتين فوق مستوى القراءة الفعلية للطلبة. أما كتاب مرحلة الصف 9 تمثل أعلى فئة عمرية واحدة وتوافقت هذه النتائج في سياق التحديات التعليمية للعلوم مع التركيز بشكل خاص على كيفية استخدام معلمي العلوم للكتب الدراسية لتقلي لتأثيرها مع مراعاة المعرفة العلمية وخصائصها.

وجاءت التوصيات محددة لعمل المؤلفين والمدرسين مسؤولية تحقيق التوازن بين المحتوى من حيث الموضوعات التي تصف المعرفة العلمية وتحسين مستوى القراءة للكتب العلمية. وعلاوة على ذلك، يلعب معلمي العلوم دورا رئيسيا في رفع قدرات القراءة لدى الطلاب عن طريق استخدام استراتيجيات التدريس المختلفة.

وبناء على نتائج الدراسة الحالية، تم تقديم اقتراحات للبحوث المستقبلية. ومنها دراسة مدى ادراك معلمي العلوم لمفهوم المعرفة العلمية الذي قد يقدم نتائج تمكن من مواجهة الخلل في مواضيع المعرفة العلمية في هذه الكتب. ودراسة كيف يمكن للمعلمين تنشيط الضوء بشكل واضح على العلاقة بين العلوم والتكنولوجيا والمجتمع الذي قد يؤدي إلى إدراك أن العلوم هي أكثر من مجرد معرفة علمية. بالإضافة إلى ذلك، التحقيق في مدى تأثير ضعوبة نصوص كتب العلوم على الطلاب في مستويات مختلفة لتحقيق القراءة الفعالة.

كلمات البحث المفتاحية: المعرفة العلمية، المقروئية، مستوى القراءة لدى الطالب، قياس المقروئية، مناهج العلوم بدولة الإمارات العربية المتحدة، الحلقة الثانية.

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Dedication

To the spirit of my father, who taught me perseverance and persistence.

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Glossary

Scientific Literacy: is the capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.

Also, **Scientific Literacy** is the knowledge and understanding of scientific concepts and processes required for personal decision making, participating in civil and cultural affairs and economic productivity.

The essence of **Scientific Literacy** is the ability to use scientific knowledge to make informed personal and societal decisions.

Science as a Way of Thinking: This theme describes how a scientist experiments, shows the historical development of an idea (how science proceeds by inductive and deductive reasoning) gives cause and effect relationship, and brings out how science is a discipline disposed to self-examination.

Science as a Way of Investigating: This theme reflects the active aspect of inquiry and learning which involve the students in the methods and processes of science. It stimulates thinking and doing by asking the students to find out.

Science as a Body of Knowledge: This theme presents and discusses facts, concepts, principles and laws. It presents hypotheses, theories and models and requires the recall of knowledge or information.

Science and Its Interaction with Technology and Society: This theme illustrates the impact of science on society. This aspect of Scientific Literacy pertains to the application of science and how technology helps or hinders humankind. It involves social issues and careers.

Readability: Readability is defined as the relative ease or difficulty of printed material or the quality of reading material that makes it understandable for those for whom it was written. In current study it means that how a student from grade 6 to 9 is capable of reading as well as understanding a context in a scientific textbook.

Student reading level: Student reading level is defined as a measurement of a student's ability to read and comprehend the English language. It is generally stated in terms of grade-level, which is determined from the student's score on the reading section. In this study, it is defined as the analysis of the reading levels of students compared with the level to the reading levels of science textbook using cloze test results.

Cloze Readability Test: Cloze Test a measure of reading levels of students. It is constructed by deleting every fifth word from a passage, the deleted words are replaced by underlined blank spaces of a uniform length, and the tests are mimeographed.

Fry Readability Graph: The 1971 Fry Readability Graph is a graph used to estimate readability levels by plotting sentences per-100 words and syllables per -100 words on a graph. The sentence and syllable counts are based on an average from three 100 word passages randomly selected from the user's material. The Four books used in this study ranged from sixth grade to ninth grade.

Cycle 2: A new grade level system used to describe the preparatory stage level of education system that includes grades 6 – 9 of 12- 14-year old students.

Chapter 1: Introduction

1.1 Background

Textbooks are one of the resources that help learners acquire knowledge. Usually, students and teachers acknowledge science textbooks as one of the main sources of scientific knowledge during the course of learning. The ability to read them is also one of the skills by which educational curricula achieved the goals for which they are stated (Al-Jawarnah, 2008). Research from numerous countries suggests that science instruction in schools are generally heavily based on science textbooks (Fang, 2006; Ginsguger-Vogel & Astolfi, 1987; Groves, 1995; Otero & Campanario, 1990; Stern & Roseman, 2004)

Science textbooks continue to be a major component of science instruction throughout the nation. These teaching aids are used widely and frequently in science classrooms (Exline, 1984; Harms & Yager, 1981). In many classrooms, they provide the majority of the instructional support beyond the teacher. Science textbooks contain much of the scientific information students receive (Mayer, 1983), which influences how students perceive the scientific enterprise. Reading science texts seems to be a particularly painstaking endeavor for students whether these texts are written in their native tongue or in a foreign language (Fang, 2006).

Science texts in general constitute a distinctive genre characterized by a complicated, rigid organization, a large number of technical and non-technical words, long nominal phrases, sentences dense with information, and complicated syntactic structures (Fang, 2006; Halliday, 1993; Gee, 2001; Groves, 1995; Sutton, 1998; & Parkinson, 2000). Textbooks are the most frequently used learning support material and,

the availability of high quality textbooks is one of the critical factors in the successful implementation of educational reform (Asmal, 1999; Cocking, Mestre & Brown, 2000; & Department of Education of South Africa, 2009).

The process of reading with understanding of textbooks is closely associated with the appropriateness of the content of textbooks; to the level of student cognitive, mental and psychological readiness (AL-Swidi & Al-Khalili, 1997). This means that the student's ability to comprehend scientific content, vocabulary and terminologies is closely related to their ability to read the textbooks. For many years, researchers have found that teachers rely heavily on the use of textbooks. It follows that we can state that it represents the main source that teachers and students rely on when learning science. More recently, a number of studies have reported on the values that students and teachers can draw from textbooks and how they can serve the learners (Tairab, 2006). For example, textbooks serve both learners and teachers in many ways - Learners use them as tools for learning and teachers use them as tools for guiding their teaching. Textbooks greatly influence how content is delivered and, indeed, how it is internalized by the learners. Schmidt, McKnight, & Raizen (1997) identified textbooks as playing an important role in making the leap from curricular intentions and plans; to classroom activities and learning by making content available, organized, and set out learning tasks in a form designed to be appealing to students. Earlier in the 1980s, a study reported that over 90% of all science teachers use a textbook 95% of the time; hence the textbook becomes the course outline, the framework, and the parameter for students' experience, testing, and a worldview of science (Yager, 1983).

Textbooks can directly relate to students' learning (Nimmo, 2001), as they largely determine what topics and ideas are taught in classrooms and how these topics are taught (Stern & Roseman, 2004). It is therefore important that they should be designed, written, and chosen as a means of learning in ways that match and align with the student learning goals that the educators and the curriculum developers have identified as an integral to the understanding of the subject matter.

1.1.1 Scientific Literacy and Science Textbooks

Scientific Literacy (SL) is one of the main educational goals worldwide, and the evidence to support this is found in a number of areas, which include curricula prescriptions, and professional and political discourse (McEneaney, 2003; & Roberts, 1983). Scientific Literacy is a broad term and there is no consensus among science educators on its definition. However, Scientific Literacy involves individuals developing sound understanding of scientific facts, the scientific inquiry process, and an awareness of the relationships among science, technology, and society (Bauer, 1992; & NRC, 1996). Because of the importance placed on the acquisition of Scientific Literacy, science education must meet the challenges of improving Scientific Literacy among students (Maarschalk, 1988; & Roberts, 1983).

Beyond science education reforms, science teaching materials, including textbooks should promote the development of Scientific Literacy by providing a balanced representation of the many aspects of Scientific Literacy. For example, Chiappetta, Fillman, & Sethna (1991) suggested that in order to effectively achieve Scientific Literacy among students, science curriculum materials should emphasize the following themes: Basic knowledge of science; investigative nature of science; science

as a way of knowing; and interaction of science, technology and society. In addition, they synthesized these four themes of Scientific Literacy from various research studies (Collette & Chiappetta, 1986; Harms & Yager, 1981; & Garcia, 1985), and the National Science Teachers' Association's (NSTA) 1982 position on SL. These four themes of Scientific Literacy have become the main elements in contemporary science education reform documents (AAAS, 1993), national science education standards (NRC, 1996), national education policies, and school science curricula worldwide.

Several science textbooks have been analyzed to establish the representation of the four themes of Scientific Literacy mentioned above (Baarah, 1991; BouJaoude, 2002; Chiappetta et al., 1991a; Chiappetta et al., 1993; Fillman, 1989; Garcia, 1985; Laugksch, 2000; Lumpe & Beck, 1996; Mumba, Chabalengula & Hunter, 2006; & Wilkinson, 1999). In general, these studies report that in the basic knowledge of science, the aspect of "Scientific Literacy" is the most emphasized theme followed by "science as a way of investigating" theme, less on "science as a way of knowing", and even less on the "interaction of science, technology, and society" theme. However, none of these studies has provided an explanation for the unequal representation of the four themes of Scientific Literacy in science textbooks.

Recent science education reforms in the United Arab Emirates have clearly emphasized the role of scientific and technological literacy in shaping the future development of the country. Most of these studies have proposed promising goals for the future and direction of education. Among the goals frequently appearing in most of the recent curriculum documents developed by the Ministry of Education (MOE), including vision 2020, is to help students acquire the scientific and technological literacy so that

they can "have better future choices, lifelong learning skills, and consequently better living standards" (MOE, 1999). Moreover, in order to achieve the stated goals, the MOE has called for basic reforms to be included in the teaching learning processes through diversification and differentiation of instruction that take into account the student diverse backgrounds and capabilities. Consequently, diversification and differentiation necessitate that learning resources, including textbooks should be appropriate for the learners so that intended outcomes can successfully be achieved.

With the increased realization of the importance of these reforms, new generations of textbooks and learning materials have recently been introduced to the field of education in the United Arab Emirates. The selection of these textbooks to be used as resources for learning was governed by the relevance of the content and the degree of correspondence with the stated learning outcomes. While the selection of textbooks can be regarded as expert-based, there is very little or no apparent research based evidence to support and validate the usefulness of these textbooks. Educators, therefore, need to determine the extent to which these newly developed textbooks focus on covering and developing Scientific Literacy among the learners and assess how well these textbooks effectively support the attainment of those specified learning goals. The only way to gain this information is through careful and systematic evaluation of textbooks. Hence the need for this current research arises.

1.1.2 Readability of Science Textbooks

In order to meet the purpose for which textbooks are designed, researchers have suggested that textbooks should be appropriate for learners to use so that they can benefit from them. As such, readability of textbooks becomes an important avenue for researchers to pursue. It also promotes conducting research studies to establish

readability indices for textbooks. Readability is the product of interaction of the reader with materials presented in the textbook. After the completion of the process of reading through the successive stages of differentiation, it shows that there is compatibility between them. Readability is what makes some textbooks easier to read than others. It is often confused with legibility, which is concerned with the typeface and layout of the textbook. Klare (1963) defines readability as "the ease of understanding or comprehension due to the style of writing". This definition focuses on the writing style as separate from issues such as content, coherence, and organization. In a similar manner, Hargis and her colleagues (1998) stated that readability is the ease of reading words and sentences, and as such is an attribute of clarity. Dale & Chall (1949) provided a more comprehensive definition as:

> The sum total (including all the interactions) of all those elements within a given piece of printed material that affect the success a group of readers have with it. The success is the extent to which they understand it, read it at an optimal speed, and find it interesting. (p23)

Despite the various definitions of the readability suggested by the researchers, they generally agree on the notion that it means the ability to read appropriately with understanding and comprehend the content presented in the textbook. As such textbook readability can be related to the extent to which the textbooks are appropriate for the age level of the reader.

Given the importance of reading science textbooks, researchers have conducted many studies to determine the read ability level of science textbooks (Wait, 1987). Lin, (1990) analyzed the books of Earth Sciences (Geology) used in schools in Taiwan and

found significant problems with the way they present information to students. For example, Lin discovered that the textbooks offer students with the problem, the procedures and the results before the experiment, and that the questions minimally measure the students' mental capacity, focusing only on memorization of information. Johnson (2001) reported in his study that the readability of the reviewed textbooks did not rise to the required level of education. Johnson (2001) focused on comparing the readability of textbooks of physics at different level. The study showed that the level of readability of physics textbooks was low and did not reach the limit accepted for these books, and readability of these textbooks were higher than the level age of the students. It is therefore, imperative that textbooks must provide the right content and instructional support in levels of readability that is appropriate for all students.

Textbooks in the United Arab Emirates constitute important learning resources for many students and teachers, as suggested by Bano, (2005) Textbooks are considered as the sole and legitimate source of knowledge for both students and teachers. Much has been achieved since the early 1970s but efforts are now being made to improve the educational environment for all pupils, in line with a re-evaluation of the government. In particular, Abu Dhabi Education Council (ADEC) is spearheading privatization of the education sector in Abu Dhabi. More recently, reforms have been influenced by English Language Education systems. The upgrading of English Language skills and use of computer technologies are government priorities, as the traditional school education in the UAE had been based on Arabic and Islamic culture and teacher-centered learning methods. In Abu Dhabi, curriculum formulation for school level is the prime responsibility of the Abu Dhabi Education Council (ADEC) and Ministry of Education. Abu Dhabi Education Council (ADEC) develops and regulates curricula for all school

subjects from pre-primary (Early Childhood Education) to secondary by involving subject and pedagogical experts from local and foreign institutions. All textbooks that are recommended for use in Abu Dhabi schools were approved after careful evaluation by ADEC. However, with all the measures put in place by ADEC, it is generally recognized that there are deficiencies in the way in which textbooks are used by students and teachers.

1.2 Statement of the Problem

Much has been said about the mismatch between the content presented in science textbooks, their reading level and the cognitive readiness of the learners in UAE. The present study focuses on Scientific Literacy and readability analyses of science textbooks used in grades (6 - 9). The lack of systematic research findings concerning the suitability of textbooks at these educational levels, has given rise to conceptualizing the problem of this research.

The purposes of this study, therefore, were to examine the nature and extent of Scientific Literacy themes coverage in the science textbooks of the Cycle 2 schools, and their readability levels in relation to the cognitive readiness of students at Cycle 2. In particular, the study was interested in establishing the nature and extent of the Scientific Literacy themes representation across and within the science textbooks at the Cycle 2 education level in the UAE, and to examine the readability of these textbooks and find out to what extents these textbooks are suitable for achieving the purpose for which they were developed.

1.3 Purpose of the Research

Readability is an important construct for both educators and textbook authors. Finding the right fit between students' reading ability and text difficulty is an important and challenging task for teachers (Fry, 1977). This study is therefore specifically set to:

1. Identify the aspects of Scientific Literacy (themes) that are emphasized by the science textbooks used in Grades 6 - 9 of Abu Dhabi Education Council schools (ADEC).
2. Assess the readability level of science textbooks used in Grades 6 - 9 of Abu Dhabi Education Council schools (ADEC).
3. Compare progression of readability indices of Grade 6 - 9 of Abu Dhabi Education Council schools (ADEC).

1.4 Research Questions

Since the quality of science textbooks has a significant impact on teaching and learning of science students, this study is designed to find answers to the following questions:

1. How does science textbooks used in grades 6 - 9 of Abu Dhabi Education Council schools (ADEC) represent the themes of Scientific Literacy?
2. What are the readability indices of science textbooks used in grades 6 - 9 of Abu Dhabi Education Council schools (ADEC)?
3. How are the readability indices of these textbooks progress through the grade levels of Abu Dhabi Education Council schools (ADEC)?

Previous research studies have mainly focused on defining levels of Scientific Literacy and the superficial alignment by topic heading to state learning outcomes. It is intended in this research to examine science textbooks in relation to their abilities to develop aspects of the Scientific Literacy among students, using criteria drawn from the best available research about how students learn.

1.5 Significance of the Study

The challenge in assessing readability is not only to determine how difficult a textbook is to read, but to match the learner's reading ability with the textbook reading difficulty. According to Freeman & Person (1998), "textbooks have simultaneously been criticized for being both too easy and too difficult". Accordingly, the importance of this study is to provide evidence-based data in relation to the reading level of these textbooks and, help curriculum planner to identify future science textbooks. Moreover, they need to provide recommendations based on evidence.

1. Students: It is a vital skill for students to know how to read properly in order for them to gain accurate vocabulary and knowledge, which can assist them in getting wide knowledge from any scientific textbook. Thus a vocabulary introduction to each section being taught should be introduced.
2. Teachers: Students who are not good enough in reading will make the teacher's job more difficult than needs be, which will also affect other student's performances negatively. Furthermore, it will be a waste of time to re-explain and translate a certain lesson in a scientific textbook rather than beginning a new one.

3. Curriculum developers: there are two things which should be under consideration. On one side, developers should not make scientific textbooks too complex, because both teachers and students will not use it efficiently. On the other side, scientific textbooks should be easier and more exciting in order to catch the student's attention and to achieve the curriculum developers' goals in spreading knowledge, but with more benefits.

It is important therefore in contexts such as UAE where students rely heavily on textbooks that these textbooks must be assessed for content representation of valuable scientific knowledge and readability level. This is because reading with understanding of textbooks is closely associated with the appropriateness of textbooks to the level of student cognitive, mental and psychological readiness and thus, attainment of learning outcomes is very much becoming a function of both appropriateness of the coverage of content and the reading level of that content.

1.6 Limitations

Despite the importance of content analysis of science textbooks in terms of representation of Scientific Literacy themes and readability levels, there is an opportunity here for the students to make effective use of these textbooks. There are some limitations and constraints that work against the exploration of this opportunity as brought forward above. The limitations of this study therefore can be summarized in two main points:

1. This study is limited to analyzing one chapter from each science textbook from the materials presented in these textbooks. Thus, in so doing this may limit the generalization of this study.
2. The study is a small-scale investigation with only students selected from two schools participating as a sample for this study. Therefore, findings may be interpreted with caution.

1.7 Definition of Terms

The following terms are defined to communicate more precise meanings peculiar to this study.

Scientific Literacy: is the capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (OECD, 2003).

Also, Scientific Literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participating in civil and cultural affairs and economic productivity (National Science Education Standards, 1996). The essence of Scientific Literacy is the ability to use scientific knowledge to make informed personal and societal decisions (Lederman & Lederman, 2005). The present study adapts these two perspectives offered by OECD (2003) & Lederman and Lederman (2005). Taking into consideration these perspectives, the following terms were also defined using the following definitions:

Science as a Way of Thinking: This theme describes how a scientist experiments, shows the historical development of an idea (how science proceeds by inductive and deductive reasoning) gives cause and effect relationship, and brings out how science is a discipline disposed to self-examination (Udeani, 2013).

Science as a Way of Investigating: This theme reflects the active aspect of inquiry and learning which involve the students in the methods and processes of science. It stimulates thinking and doing by asking the students to find out (Udeani, 2013).

Science as a Body of Knowledge: This theme presents and discusses facts, concepts, principles and laws. It presents hypotheses, theories and models and requires the recall of knowledge or information (Udeani, 2013).

Science and Its Interaction with Technology and Society: This theme illustrates the impact of science on society. This aspect of Scientific Literacy pertains to the application of science and how technology helps or hinders humankind. It involves social issues and careers (Udeani, 2013).

Readability: Readability is defined as the relative ease or difficulty of printed material or the quality of reading material that makes it understandable for those for whom it was written (Pride, 1987). In the present study, readability is intended to reflect the level with which students can read these textbooks with understanding.

Student reading level: Student reading level is defined as a measurement of a student's ability to read and comprehend the English language (Pride, 1987). It is generally stated in terms of grade-level, which is determined from the student's score on the reading section. In this study, it is defined as the analysis of the reading levels of students compared with the level of the reading levels of science textbooks using Cloze Test.

Cloze Readability Test: Cloze Test is a measurement of reading levels of students (Taylor & Wilson, 1953). It is constructed by deleting every fifth word from a passage; the deleted words are replaced by underlined blank spaces of a uniform length.

Fry Readability Graph: The 1971 Fry Readability Graph is a graph used to estimate readability levels by plotting sentences per-100 words and syllables per -100 words on a graph. The sentence and syllable counts are based on an average from three 100-word passages randomly selected from the user's material. Four books used in this study ranged from sixth grade to ninth grade (Filming, 1977).

Cycle 2: The Ministry of Education has adopted an educational development strategy called 'Education 2020', based on successive 5-year plans. A new grade levels system was introduced into government schools, as such (Cycle 2) the preparatory stage caters for children aged between 12 to 14 years. That exactly mean in the current study.

1.8 Organization of the Study

The study is organized in five chapters. Chapter 1 has introduced the research problem, highlighted the purpose, the research questions, the significance of the current study, as well as defining the key terms and identifying the limitations of the study.

Chapter 2 has provided further understanding of how previous research studies investigated the scope and depth of how Scientific Literacy is represented in science textbooks, and how authors conducted the readability analysis studies. The review of literature has provided a framework through which the importance of the focus on analysis of the representation of Scientific Literacy and readability levels in science

textbooks of Cycle2 schools is revealed in order to ascertain what we grasp about this research problem.

Chapter 3 on the other hand has focused on the methodologies used to find answers to the research questions asked in chapter 1 including the procedures followed and to collect data and analyze these data. The results of data analyses and findings emerged from the study were presented in chapter 4.

Finally, chapter 5 presented a summary of the study and the major findings, conclusions drawn from the findings, a discussion, implications, and recommendations for future studies.

Chapter 2: Literature Review

2.1 Introduction

This chapter presents and reviews essential findings of related previous studies in the area of science textbooks analyses, Scientific Literacy and readability. Particularly the chapter focuses on findings that showed the analysis of Scientific Literacy and readability of science textbooks that were related to the level of student readability. This literature review, illustrates different areas of investigation, the science textbooks quality including science textbooks functions and characteristics. It also investigates learning and teaching from them. On the other hand, it examines the major defining readability and researcher's opinion as well as the factors affecting the readability of science textbooks, and the tools used for analyzing the readability of science textbooks.

2.1.1 Studies Related to Textbooks in General

Science textbooks must represent Science in a way that supports learners in mastering the discipline. They also serve both learners and teachers in many ways; Learners use them as tools and tutors whereas, teachers use textbooks as a guide to their teaching. Moreover, textbooks greatly influence how the content is delivered, and indeed, how the learners internalize it. Learning from textbooks adds another dimension to the complexity of the learning process particularly the dimension of texts and information processing. Schmidt, Mcknight, & Raizen (1997) identified textbooks as playing an important role in making the leap from intentions and plans to classroom activities and learning by making content available, organizing it, and setting out

learning tasks in a form designed to be appealing to students. Earlier in the 1980's, a study reported that over 90% of all science teachers use a textbook 95% of time; hence the textbook becomes the course outline, the framework, the parameters for students' experience, and for testing, a worldview of science (Yager, 1983).Textbooks can directly relate to students' learning (Ninnes, 2001), as they largely determine what topics and ideas are taught in classrooms and how these topics are taught (Stern & Roseman, 2004). Subsequently, it is important that they should be designed, written, and chosen as means of learning in a way that matches and aligns with the student learning goals that the educators and the curriculum developers have identified as integral to the understanding of the subject matter.

Science education research has extensively discussed the use of textbooks and the ways of conceptualizing and writing them especially for students (Klassen, 2006). Teachers have to face many challenges in their work (Anderson & Helms, 2001) in order to select and choose the appropriate textbooks. For example, Fang (2006) encourages teachers to use paraphrasing exercises as they could serve as a way to transform the scientific language into everyday language. Henson (2004) summarizes three ways for teachers to use textbooks: Some try to avoid using them at all; the second group centers their teaching on the textbook and supports it with other books, journals and newspapers and the third group of teachers design their own curriculum and just use the textbook along with other media as supplementary material.

Learners can only learn from textbooks that they can read and understand, though textbooks are often difficult to understand (Hsu & Yang, 2007). Consequently, the comprehension of texts deserves further discussion. Research from numerous countries suggests that science instruction in schools is generally heavily based on

science textbooks (Fang, 2006; Groves, 1995; Ginsguger-Vogel & Astolfi, 1987; Otero & Campanario, 1990; Stern & Roseman, 2004).

One of the major problems confronted by English as a second language learner in learning science is the lack of language proficiency. Yong (2010) affirms that if the understanding of textbooks language is difficult for English speakers, it is likely to be even more difficult for students who learn science in a second language. As reported by Duran, Dugan & Weffer (1998) language minority students in schools did not have the necessary linguistic tools to construct advanced science concepts. As a consequence they have weak scientific knowledge because of their inability to construct scientific concepts and meanings effectively due to their low-level English skills. Furthermore, it has long been recognized that students encounter enormous problems learning science in a second language (Mohiddin, 2007; Romaizah, 2009; & Yong, 2003).

It has been approved that in science education, language is no longer an incidental medium through which students express their thoughts and reach better understanding. It is rather vocabulary and grammar to master before entering science classes. Hence, language can become an impediment to learning in the way it leads to many misconceptions (Boujaoude & Sayah, 2000). It is obvious that without a foundation in scientific glossary, and lack of the developed skill in learning, students have low achievement in science.

Textbooks have significant roles as they are considered as "primary vehicles for delivering content knowledge, determining in large measures what goes on in a class" (Lebruny, Lenoir, Laforest … and Pearson, 2002), and for assessing what students do and do not learn (Oakes & Saunders, 2004). A majority of teachers consider textbooks

as the only teaching resource (Maffia, Dias, Brauna & Cruz, 2003). Textbooks do not only influence what and how students learn, but also what and how teachers teach.

Johnsen (1993) discussed the concept of "textbook authority" as a complex concept and can have both positive and negative implications. What authority the textbook exerts in a classroom depends on how the learners and teachers view textbooks and respond to them (Kesidou & Roseman, 2002). Apple & Christian-Smith (1991) identified three ways in which people can possibly respond to texts: Dominated, negotiated, and oppositional. So, they can accept the content of a textbook as a face value, or a reader may dispute a particular claim, but accepts the overall interpretation of a text, and others reject the dominant tendencies and interpretations in texts.

The quality of a textbook is a complex issue and it is not immediately apparent what a good textbook must look like. A good textbook was defined as one that has the potential to support the learner and teacher in attaining the desired science learning goals. Therefore, a good textbook is a textbook that incorporates characteristics that enable it to support the learners and teachers (Davis, 2003b). A good textbook has the potential to offer substantial and significant support to teachers. In the case of under-qualified teachers, textbooks and exemplary materials are often the only sources of guidance and support readily available (McKenney, 2001; Newton & Newton, 2006; & Ogan-Bekiroglu, 2007).

Consequently, the presence of these characteristics in a textbook will indicate its quality or its potential to support both the learner and the teacher. The complexity of the problem of identifying the characteristics that indicate textbook quality, demands a systematic approach to the problem. The overall purpose of supporting the learner and the teacher can be broken down to a number of separately identifiable functions that

contribute to fulfilling the overall purpose. The purpose of science education textbooks is to support teachers and learners through learning process (Garcia-Barros, Martinez-Losada, Vega & Mondelo, 2001; & Litz, 2001). Kesidou & Roseman (2002, 523) asserted that textbooks:

"... Provide a coherent science program for students based on the best thinking available in the field, and material that supports teachers in making more thoughtful and informed decisions about their own science student's learning."

2.1.2 Studies in Scientific Literacy

The theoretical framework of this study is presented from the Scientific Literacy and the readability perspectives. Scientific Literacy has recently attained the status of a universal and a central educational goal (Holbrook & Rannikmae, 2007; & McEneaney, 2003). National educational systems around the world assume that the demands of a modern, increasingly technology-oriented economy require a workforce that has a universal minimum level of understanding of science as described by Bybee (2009), he considered that Scientific Literacy is best described as a continuum of understanding about the natural and the designed world to reflect the status of being well-educated and well-informed in science, as opposed to merely understanding scientific vocabulary. He suggested a broad framework, which describes certain thresholds that identify degrees of Scientific Literacy.

Murphy, Beggs, Hickey, O'Meara, & Sweeney (2001) used the term 'Scientific Literacy' to refer to being informed in science with the minimal scientific knowledge and skills required to access whatever scientific information and knowledge is desired.

The National Research Council (1996) defined Scientific Literacy as the knowledge and understandings of scientific concepts and processes required to make personal and societal decisions. NRC went further to identify categories that characterize Scientific Literacy.

Scientific Literacy can be viewed as a combination of themes that reflect aspects advocated in science education. For example Scientific Literacy can be viewed as knowledge, as a procedure (investigative knowledge), as a way of knowing, or as a way of impacting societies (Boujaouda, 2002; Stern & Roseman, 2004).

Science textbooks remain fundamental tools in developing Scientific Literacy (Penney, Norris, Philips, & Clark, 2003) and there by provide an avenue for life-long learning in science as they are the ultimate source of science knowledge in many science classrooms (Tairab, 2006). Recent studies indicated that many science teachers rely on textbooks to provide them with some of or all the content or the pedagogical content knowledge (Stern & Roseman, 2004) to the extent that, in many ways, they become the embodiment of science for students (Musheno & Lawson, 1999). As such, science textbooks are clearly positioned to affect profoundly the learning experiences of students. Hence, poorly developed textbooks can deprive both students and teachers of ways that allow them to understand and implement effective teaching practices.

Chiappetta, Fillman, & Sethna (1991) developed a framework to capture Scientific Literacy in terms of four themes: (a) *the knowledge of science,* (b) *the investigative nature of science*, (c) *science as a way of thinking* and (d) *the interaction of science, technology, and society*. The theme of *"Knowledge of Science"* is used to imply that the content of the scientific materials is meant to present, explain, or ask the student

to recall information, facts, concepts, principles, laws, theories, hypotheses, and models etc. - meaning that the focus is on science as a body of knowledge and the transmission of scientific knowledge.

The theme of "*The Investigative Nature of Science*" is used to denote that the content of the scientific materials is meant to engage the learner and stimulate thinking by challenging students to use and apply inquiry behaviors. Thus, the theme reflects the active nature of scientific inquiry and application of processes of science, such as observing, measuring, classifying, inferring, recording data, making calculations, experimenting, etc.

On the other hand, the theme of "*Science as a Way of Thinking*" implies that the content of the scientific materials is used to illustrate and describe how scientific information is discovered and how scientists went about establishing scientific evidence. In addition to reasoning and thinking, reflective behaviors of scientists are also emphasized in this theme. It is expected that the content of the scientific materials in this theme will not only describe how scientists experiment but also show the historical development of an idea; and emphasize the empirical nature and objectivity of science.

Finally, the theme of "*Interaction of Science, Technology, and Society (STS)*" is used to denote that he content of the scientific materials is meant to discuss and explain the impacts of science on society. Thus, it is expected that scientific materials in this theme will tend to describe the influences of science and technology on society and recognize the negative effects of science and technology on the society, and further discuss social issues related to science or technology (Chiappetta, Fillman, & Sethna, 1991).

Using these themes, a number of studies were carried out to assess high school chemistry textbooks (Chiappetta, Fillman & Sethna, 1991), biology textbooks (Boujouade, 2002; Lorsbach, & Moore, 2008; Lumpeand Beck, 1996; & Udeani, 2013), and physics textbooks (Mumba, Chabalengula, & Hunter, 2006; & Wilkinson, 1999) and general science (Cakici, 2012; & Tairab, 2006). Other areas of knowledge were also investigated such as, mathematics and science textbooks (Valverde, 2002).The findings of these studies generally reflected that most science textbooks lack a balanced representation of the themes, with the 'Knowledge of Science' theme receiving the most coverage and more focus across all these studies. Very little coverage was devoted to the "*the Investigative Nature of Science*" and 'science as a way of thinking' themes. However, there was evidence that newer textbooks tended to represent Scientific Literacy in terms of interaction of science, technology and society.

Moreover, the study of Erdogan & Koseoglu (2012) examined 9th grade physics, chemistry and biology curricular that were implemented by the Ministry of Education in Turkey since the academic year 2008-2009. Their findings also showed an unbalanced representation in terms of scientific literacy themes.

Taking into consideration the findings of previous studies, it is therefore, imperative that textbooks must provide the right content and instructional support. Science textbooks must cover the key ideas that students need for literacy. They must also provide research-based instructional strategies that teachers can use to help students learn scientific ideas. In 1998, after developing and field testing a rigorous procedure for analyzing curriculum materials, Project 2061 of the American Association for the Advancement of Science applied the procedure to middle- and high-school textbooks to

see how well they align with standards and how well they help students achieve them (AAAS, 2001). This study probed beyond a superficial analysis of alignment by topic heading and examined each text's quality of instruction aimed specifically at key standards and benchmarks, using criteria drawn from the best available research about what helps students learn. The results suggested that out of texts analyzed (10 middle-grades science texts, and 10 high school biology texts), only one physical science textbook was found to be satisfactory, that is, having a high potential for helping students learn ideas that are essential for science literacy. The rest of textbooks were found to be unsatisfactory with little potential for helping students learn important ideas and skills. Furthermore, from the above findings specific results pertaining to the high school biology textbooks revealed that essentially all students, even the best and the brightest have predictable difficulties grasping many ideas that are covered in the textbooks. Yet, most textbooks fail to take these obstacles into account in the activities and questions. It was also found that for many biology concepts, the textbooks ignore or obscure the most important ideas by focusing instead on technical terms and superfluous detail, the sorts of material that translate easily into items for multiple choice tests (AAAS, 2001). While most of the books are lavishly illustrated, these representations are rarely helpful because they are too abstract, needlessly complicated, or inadequately explained (Roseman, Kulm, & Shuttle Worth, 2001).

2.1.3 Studies Related to Textbook Readability

The challenge in assessing readability is not only to determine how difficult a textbook is to read, but to match the learner's reading ability to the textbook reading difficulty. The term 'readability' refers to what Fry (2002, p. 286) calls 'true

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readability', which is the ease with which a text or a passage may be read and the extent to which it is interesting to read. This definition contains a subjective dimension that distinguishes it from approaches involving the mere application of readability formulae.

The readability of a text – in this case a scientific text or passage – implies the extent to which readers can read and make sense of the text or passage rather than reading. Because reading involves interaction with written texts, language proficiency is considered to be necessary in order to effectively understand the text. In other words, reading is a 'reasoning task connected to a language task' (Swaffar, 1988, p. 141). Hence, students need to learn and understand scientific language in order to comprehend the scientific concepts and acquire the needed communication and thinking skills (Kearsey & Turner, 1999).

Various researchers have reported that students find science a "forbidding and obscure" (Halliday, 1993, p. 69) subject and that reading a science text is a difficult enterprise that can be frustrating (Fang, 2006). But, research suggests that problems faced by second language learners are not very different from those faced by native speakers: Both encounter similar challenges when reading science texts as 'science language' includes features that are peculiar to science, that is, the scientific register (Fang, 2006; Halliday, 1993; and Kern1989).

According to Freeman and Person (1998, 12) "textbooks have simultaneously been criticized for being either too easy or too difficult." Texts that are easy for a reader to process reduce the amount of active processing. The level of the text must be matched to the level of the reader's ability (Burns, 2006 & Fry, 2002). It is necessary to keep in mind the fact that reader's characteristics like motivation, interest, purpose and

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perseverance in the reading test situation may differ from the same reader's characteristics when reading science texts (Guthrie & Wigfield, 2005).

The readability of a text depends on various characteristics; according to (Bamberger, 2000) the most important ones are: the difficulty or complexity of content, the difficulty of the language itself, the quality of style, the readability of the print as well as the reference to the reader. The understanding students gain from reading texts is influenced by many characteristics, some of which can be influenced by writers and other that cannot. Background knowledge, education, language skills, and the reader's environment are among those that cannot be changed by the writers of texts. However, several other factors can be influenced to increase understanding. For example, the vocabulary used, the complexity of sentences, the density of information in a text, and the composition of documents are among those factors that can be manipulated. Some factors will influence perceived difficulty of a text, others will influence actual difficulty, and some may influence both.

The number of words in a sentence, the number of syllables in a word, the number of ideas emphasized in a sentence, and the continuity of the ideas in a text are the properties determining readability (Tekbiyik, 2006). According to Gunes (2003), short and simple structured sentences are better learnt than long and complex structured sentences. It is important to take word sentence lengths into consideration and as age increases, word and sentence lengths can also increase (Cecen, Ciftic, & Melanlioglu, 2007).

A study conducted by Abu El-Sheikh, Suelmyin, & Awamleh (2010) aimed to determine readability level of science textbook among the 7th grade students in Jordan,

as well as to explore the effect of gender on the readability level, and text order according to its readability level in the textbook. The study results revealed that students' performance in the readability level of the textbook was within the low depression level also, there were significant differences in respect of gender revealed that students performance in the readability level were in favor of female students. The results also revealed that the reading texts in the textbook weren't scaled according to the readability level.

Due to the importance of reading science books, has conducted, some studies have been conducted to detect the level of study aimed to assess the readability of science books (Wait.1987), English and social studies assessments for students in the fourth, fifth and sixth grades primary enrolled in the school of research development at the University of Florida in the United States, and to measure the level of readability of the books, where the study results showed a statistically significant differences between the levels of readability books for grades fourth and fifth without the sixth grade, results also showed that writing science for fourth and fifth grades had difficult readability of the science books prescribed for other classroom subjects. It was found that more than 90% of the students were in low level in the readability of the study sample science books.

Johnson (2001) conducted a study aimed to compare the readability of the books of physics in the years of 10^{th} and 11^{th} of education, the study has shown that the level of readability of the textbooks of physics were low and did not reach the limit accepted. Besides, readability of these books was higher than the level of the age of the students who decided to learn them. Kotaite (2002), also conducted a study aimed to identify the

level of readability of the Physics textbook scheduled second secondary grade students in Jordan and the scientific results of the study indicated that the readability of the textbook lays in the frustration level by 69% of students study sample.

Lin (1990) conducted a study aimed to analyze the books Earth sciences Geology used in schools in Taiwan and the results showed that Earth Sciences offer students the problems, the procedures and the results before the experiment. The question is that they measure the mental capacity of the student, making them remembering only. It is suggested that the level of readability is not commensurate with the level of education required.

In a study conducted by Ombosaidy & Alarimi (2004), the Biology textbook of first-grade in the secondary cycle in Sultanate of Oman was examined for the readability relationship fact with some variables such as gender and achievements in the subjects of Biology and Arabic. Four tests have been applied and these kinds of testing continued on a sample of 209 male and female students. The results of the study indicated that 56% of the study sample had a readability level on separate levels, while 32% of the study sample had independent level and 12% was at the frustration level. Results of the study showed no statistically significant differences between males and females in a separate level in favor of females, while the differences were statistically significant at the level of frustration in favor of males, while there were no statistically significant differences between males and females in the level of education. The results of the study also showed a statistically significant relationship at the two levels but it weakens when it comes to the performance of students in the reading test and their achievements in the subjects of Biology and the Arabic language.

There are important studies investigating the level of readability of science books in all academic levels. In some of these previous studies researchers have used the Cloze Test to measure the readability of science books, which is the same method used in this study, but the difference between this study and some previous ones is that it dealt with the level of readability of the science textbook for grade seven primary only, and found out whether there are differences between males and females in the level of readability or not, and in the knowledge included in scientific texts according to their location in the science textbook in light of the degree of readability, and this is what has not been considered by any of the previous studies mentioned before. Furthermore, El-Masri (2010) analyzed the readability of Year 12 biology textbook in the Lebanese high school system using both Flesch and Cloze Tests, and the reading strategies that students employ when reading science texts. The results showed that the readability of the French version of the textbook was slightly higher than that of its English counterpart according to both Cloze Test results and the Bormuth criteria as applied to the Flesch scores.

In fact, the previous studies suggested that learners reading science textbooks in language different from theirs encounter numerous problems (Lemke, 1997). They first need to simultaneously master both the science content and language at the same time (Yong, 2010). Lemke (1997) confirmed this contention by suggesting that learners have to be engaged in two tasks together at the same time when learning science; the first task is to comprehend the new language (i.e. English) and the other one is to understand the scientific content. Yong (2010) reported that generally ESL learners do not have the necessary linguistic tools to construct advanced science concepts, implying that they are more likely to underachieve in science. In addition, he reported that the readability of the

science textbook investigated far exceeds the reading age of the students. In terms of the reading level, only about a third of the students studied by Yong were found to be reading at the instructional level while the majority were found to be at the frustration level. Furthermore, Yong also found that there was a positive significant association between student reading level and achievement in science.

Merzyn (1987) reported in his study that the readability of the textbooks reviewed did not rise to the level of the required education. Yong (2010) cited other studies that found out that learning science in a second language pose a severe barrier to comprehension of the text being read. Furthermore, studies carried out with ESL learners found that the language used in science textbooks was too advanced for many of the learners (Letsoalo, 1996). These authors reported that the level of linguistic competences possessed by some year 12 (17+ years) ESL learners may be comparable to that of Year 5 (10+ years) English-speaking students. Santa & Alverman, (1991) reported that students studying science in a language other than their home language are not only challenged by the expectations of high school demands of science but also by the language experience of having to read science textbooks and derive meanings from analogy and metaphor that are frequently used in science.

The conclusion that can be drawn from these studies is that it becomes imperative that textbooks provide the right content and instructional support in levels of readability that is appropriate for all students. Because textbooks can be considered as not only an influence of what and how students learn, but also what and how teachers teach, particularly in centralized curricula such as those of UAE, where the science textbooks are written in English whilst UAE students are foreign language learners. It is therefore

important to find out whether these science textbooks provide appropriate scientific content to the students or not.

2.1.4 Studies Related to UAE Context

The United Arab Emirates has undertaken science education reforms for the purpose to achieve promising goals for the future and to direct science education to serve the development of the country. In other words, there is a need to a modern technology-oriented economy. So, students should acquire the minimum level of understanding of science as described by Bybee (2009). These reforms appeared in most of the recent science textbooks in the field of education which were adopted by the Ministry of Education and ADEC, including the vision of 2020 and ADEC aims at allowing the learners acquire the scientific and technological literacy so that they will be able to have better prospects, learning skills and consequently better living standards (ADEC, 2010).

Taking into account the rapid movement of reform in the UAE, studies related to UAE in relation to textbook analyses were rare. The search of previous research studies has resulted in limited number of studies that deal with Scientific Literacy and readability analyses. Tairab, (2006) investigated the extent of coverage of Scientific Literacy in the recently developed textbooks at the Basic education level of the UAE educational system and the potential of its contribution to the development of student realization of the stated learning outcomes. The findings suggested that the current science textbooks need to be reconsidered so that they achieve the stated learning outcomes.

A similar perspective of documenting content related conceptual understanding, Al-Naqbi & Al-Maamari (2010), examined the Sultanate of Oman and the United Arab Emirates high school social studies and science teachers' perceptions towards citizenship education. Although the results were not directly related to the theme of the present study, the findings of Al-Naqbi & Al-Maamari (2010) suggested that National Education, Social Studies, History, and Islamic Studies were the subjects that much associated with citizenship education while Science and Mathematics were less associated with citizenship education. As such these findings may be interpreted in the context of textbook analyses that suggest that topics related to citizenship education were to be taught as part of social studies not as part of science as STS content.

2.2 Summary

Taking into consideration the results found previously much importance was given to science textbooks which not only must cover the key ideas that students need for literacy, but also, they have to provide teachers with research-based instructions that they can use to help their students learn scientific ideas.

Many research studies suggested that learners reading science textbooks in a foreign language face various problems (Lemke, 1997). They need to master both the science content and the language at the same time when Learning Sciences as Yong (2010) précised. Moreover, the findings of these studies reviewed above emphasized that science textbooks should provide the right content and instructional support in levels of readability for both the learners and teachers, especially in countries that have centralized curricula like the UAE and where the learners are foreign language students.

To conclude, it is worth mentioning that the result of the research studies reviewed previously showed that textbooks have presented unbalanced views about the Scientific Literacy, presenting science mostly as a body of knowledge with less emphasis on the other themes that seemed to be advocated by most science education curricula to provide the students with the chance to face the challenges of the 21st century. This unbalanced view is most likely to affect the student conception of the Scientific Literacy and as a result the nature of the scientific enterprise.

On the other hand, findings related to readability studies showed that readability of textbooks may pose a real difficulty on most of students when reading these textbooks. So, teachers should take this into consideration providing the learners with extra resources to help them. Authors of the previously reviewed studies suggested that adoption of a bilingual approach is one of the immediate solutions to interaction in the classroom and in the investigative activities till the learners develop the needed reading level.

Based on the above literature findings, this study is expected to provide a singular avenue for analyzing textbooks used in Cycle 2 from both perspectives of both content knowledge as well as reading levels. One unique feature of the present study is that it combines the two perspectives (content and readability) to provide the readers with knowledge based that is pertaining to the UAE context.

Chapter 3: Methodology

3.1 Introduction

The purpose of this chapter is to provide a comprehensive description of the procedures used in the implementation of this study. The description includes the following: Study design, selection of the participants, selection of the research instrument, procedure for collecting the data and procedure for data analysis.

3.1.1 Design of the Study

The study is based on an exploratory descriptive content analysis design in which the content of the science textbooks at Cycle 2 were analyzed for their representation of Scientific Literacy themes and readability level. According to Oxford English Dictionary (2014), exploratory are actions that involve exploration and investigation in order to discover something or to learn about something. Burns and Grove (1998) define exploratory research as research conducted to gain new insights, discover new ideas and/or increase knowledge of a phenomenon.

Since the purposes of this study were to identify the aspects of Scientific Literacy (themes) that are emphasized by the science textbooks used in grades (6 - 9), and identify the readability level of science textbooks, the exploratory content analysis design was deemed to be appropriate for these purpose because it allows the researcher to gain insight into the representation of the Scientific Literacy themes as well as identify the reading level of each of the textbooks under the study.

3.2 Sampling

Two types of sample and sampling procedures were involved in the present study. The first sample was that which pertains to the textbooks to be analyzed and the second sample pertains to the students who use these textbooks. Textbooks were selected for their content analyses and the students were selected to identify their reading ability.

3.2.1 Sample of Textbooks

The textbooks used in this study were *Science Focus for the United Arab Emirates* (Student version), 2nd edition by Whalley, Phillips, Monckton … and Naville (2009), which were the focus of this study (Appendix A). The textbooks include four series grade levels: six, seven, eight, and nine. The textbooks were first published by Pearson Australia, in time for the implementation of the new educational policy of ADEC. All science content in these textbooks is taught as units which have been classified into four areas: Matter (*Chemical Science*), Physical World, Living World (*Biological Science*), and Earth and Space (*Geological Science and Astronomy*) and one specific skills area (*Being a Scientist*) which is covered through the four areas. The textbooks were printed in colors, diagrams, and high quality pictures. They include at the end of each unit various aspects of assessments to engage students with reading and development of scientific ideas. The assessment aspects range from thinking and problem solving activities to practical and investigative activities that aim at enriching student understanding of the four content areas presented in these textbooks.

The selected textbooks were used to answer the research questions related to representation of Scientific Literacy themes and readability levels.

The Science Focus textbook for grade 6 contains four areas presented in 358 pages, and four areas: Matter (8 units), Physical World (11 units), Living World (15 units), and Earth and Space (10 units). In grade 7 the Science textbook covers 384 pages, and four areas: Matter (11 units), Physical World (8 units), Living World (9 units), and Earth and Space (16 units). While the Science textbook for grade 8 includes four areas: Matter (7 units), Physical World (10 units), Living World (13 units), and Earth and Space (6 units), in 344 pages. However, grade 9 Science textbook comprises 313 pages in four areas divined into different and specific chapters: Chemical Reactions (4 units), Materials (5 units), Electricity and Communications Technology (5 units), Genetics (4 units), Motion (7 units), Health and Disease (5 units), Theory of Evolution (3 units), Global Issues (4 units), and Individual Research Project (2 units). Most of the topics are sequential and integrated from one grade level to another with more complexity details and depth in meaning; in grade 6 unit 1 the topic is of arranging the elements, in grade 7 unit 6 the topic metals, non-metals and semi-metals, while in grade 8 the topic is atoms and elements in unit 1. However, there are more specific in grade 9 unit 2 about pure metals and alloys.

3.2.2 The Student Sample

The sample of this study consisted of 200 students drawn purposively from two of Al Ain Cycle 2 government schools during the 2013/ 2014 academic year. One school is for boys and the other school is for girls. The total 200 participants were drawn from different grades (6 - 9). The participating students were selected randomly from the

available classes. Initial selection of these classes was based primarily on the availability and willingness of teachers to involve their students in the study. The samples consist of 103 male and 112 female students between the ages of (10 – 15) years. The female students who appeared for the test were 108 out of the participants' sample, as 4 students were absent from school on the day of the administration of the Cloze Test, while the male students who appeared for the test were 92, as 11 students were also absent on the day of the administration of the test. The distribution of these students over the four grades is shown in Table 1.

Table 1: Descriptive of the Sample

Gender Levels	Male Sts.' Num.	Attend	Female Sts.' Num.	Attend
Grade 6	30	30	29	28
Grade 7	26	22	28	28
Grade 8	27	21	27	25
Grade 9	20	19	28	27
Total	103	92	112	108
Percentage of Participation 89.3 %			Percentage of participation 96.4%	

3.3 Data Collection Methods

Data collection involved two methods; content analysis of the selected textbooks for evidence of the representation of the Scientific Literacy themes in these textbooks and identification of readability indices of the selected textbooks and the students' actual reading levels.

3.3.1 Scientific Literacy Themes

The analysis of the textual information to identify the level of representation of the Scientific Literacy themes was based on a framework developed by Chiappetta, Fillman, & Sethna (1991b) that categorized Scientific Literacy as (a) *the knowledge of science*, (b) *the investigative nature of science*, (c) *science as a way of thinking*, and (d) *the interaction of science, technology, and society*. These themes were found to associate with the description of the Scientific Literacy (Boujaouda, 2002; Stern & Roseman, 2004).

3.3.1.1 Validity of the Framework

The validity was established through the findings of present research studies. Several science textbooks have been analyzed to establish the representation of the four themes of SL (Baarah, 1991; BouJaoude, 2002; Fillman, 1989; Garcia, 1985; Chiappetta, 1991; Chiappetta et al., 1993; Laugksch, 2000; Lumpe & Beck, 1996; Mumba, Chabalengula & Hunter, 2006; & Wilkinson, 1999). In general, these studies report that the basic knowledge of science aspect of SL is the most emphasized theme followed by science as "a way of investigating" theme, less on science as "a way of knowing", and even less on the" interaction of science, technology, and society" theme.

Abd-El-Khalick (2002) reported on the images of the nature of science found in middle-level science trade textbooks that are advocated by educators. He used nature of science themes advocated by Chiappetta et al. (1998), and specifically those found in *Benchmarks for Science Literacy* (AAAS, 1993): empirical nature of scientific knowledge, durability and tentativeness of scientific knowledge, replication and

confirmation in science, the myth of the "scientific method" and the imaginative creative NOS, theory-laden nature of science, limitations of science, humanity's contributions to science versus access to the scientific enterprise, and the structure of the scientific enterprise. Abd-El Khalick concluded that the four books, selected randomly from the National Science Teachers Association list of award-winning science trade books, were devoid of any explicit reference to important elements that define the nature of science.

Erdogan & Koseoglu (2012), studied the analysis of the 9th grade physics, chemistry and biology curricula, which were implemented by the Ministry of Education in Turkey since the academic year 2008-2009, in terms of Scientific Literacy themes and the balance of these themes and also to examine the quality of statements about objectives. Analysis results revealed that the theme "the knowledge of science" in the chemistry curriculum and the theme "the investigative nature of science" in the physics and biology curricula were well emphasized, the theme "the science as a way of thinking" was not adequately emphasized in each of the three curricula. The findings of the study show that nature of science should be more emphasized in science curriculum to help each of citizens in our country become lifelong learners and have an adequate level of Scientific Literacy.

3.3.1.2 Reliability of Framework Used

In the present study, two independent researchers performed the analyses independently. To ensure reliability of the results and the accuracy of the representation of the Scientific Literacy themes in the science textbooks, 90% or above agreement between the two researchers was regarded as a cut off point for accepting the results of the analyses. Analyses were considered valid to be included directly in the results if they

meet this cut off point. Disagreements between the researchers were resolved through consensus and reaching common agreement.

3.3.2 Grade Reading Level

The readability of the science textbooks was determined by using two instruments namely the Flesch-Kincaid Grade Level Readability Formula and the Fry Graph. On the other hand, the actual reading ability of the participating students was determined by the Cloze Test. The two readability tests as well as the Cloze Test were used in this study because of their ease of use as well as their reported proven reliability in estimating the readability level of textual information and students.

3.3.2.1 The Flesch-Kincaid Grade Level Readability Formula

The Flesch-Kincaid Grade Level Readability formula is based on the number of syllables in each work as well as the number of words per sentence (Flesch, 1949). The readability of textual information is established based on calculating the average number of words used per sentence and the average number of syllables per word to provide an index that describes the reading level of a text. Scores can be interpreted as shown in the figure below:

Figure 1: Scheme of Interpretation of the Readability Level

Score	Notes
90 -100	Very easy to read
80 - 89	Easy to read
70 - 79	Fairly easy to read
60 -69	Standard – Average to read
50 -59	Fairly difficult to read
30 - 49	Difficult to read
0 - 29	Very confusing to read

3.3.2.2 Fry Readability Graph

Fry Readability Graph (Fry, 1977) is one of the most frequently used formulas in education. Fry Readability Graph is commonly used in education because of the ease of use and the reliability of indices generated by this formula. The Fry Readability Formula assigns an approximate grade reading level to a passage of text. The formula depends on the vocabulary and sentence structure of the text, not the organization or content. The grade reading level is found by plotting the average number of sentences and syllables on the Fry Readability Graph which measures reading levels from 1st grade to college years. The Fry graph was also used to determine the relative difficulty of the vocabulary or sentence length of the passages (Fry, 1979). The Fry Readability Formula depends on the vocabulary and sentence structure of the text. The readability of textual information is calculated based on the following steps:

1. Random selection of approximately four 100-word segments of a text;
2. Counting the number of syllables in each 100-word segment and calculating the average of syllables in these segments;
3. Counting the number of sentences in each 100-word segment and calculate the average of sentence;
4. Plotting the average number of sentences and the average number of syllables on the graph; and
5. Finding out the intersection of the average number of sentences and the syllables. The area in which the average number of sentences and syllables cross is the grade reading level of the text.

The grade reading level is found by plotting the average number of sentences and syllables on the Fry Readability Graph which measures reading levels from 1st grade to college years.

In the present study the readability indices of science textbooks were calculated by using online calculators and randomly selecting three passages of 100-word length and entered into the online calculator. The calculator works by counting the number of syllables in each 100-word segment and calculating the average of syllables in these segments; counting the number of sentences in each 100-word segment and calculating the average of sentence. The calculated index indicates comprehension difficulty when reading the scientific content of the textbook.

3.3.2.3 The Cloze Test

The Cloze Test, Wilson Taylor, (1953) was used to assess the actual reading ability of the students. The test measures the level of readability of educational material by students and thus, students can be classified according to the indices generated by this test. Wellington & Osborne (2001) develop a classification scheme to place students according to their Cloze Test scores as either at an independent, an instructional, or a frustration level as follow:

Table 2: Students' Reading Level in Relation to Scores in the Cloze Test

Reading level	Score	Suitability of reading materials
Independent	60-100% correct	Materials are too easy for students
Instructional	40-59% correct	Materials are appropriate for students but need teachers' support and guidance
Frustration	0-39% correct	Material are too difficult for the students

Wellington & Osborne (2001) suggested that students who obtain 60% or above in Cloze Test may be classified as independent readers at the independent level who can read with ease and always find similar materials easy to read and understand. Students who obtain a score between 40% and 59% are classified as within instructional level readers who may rely to a large extent on external support and guidance to understand textual materials. On the other hand, students who obtain scores below 40% are classified as frustration level.

In the present study the Cloze Test was used because of its established reliability and its relation to language literacy as evidenced by studies of David (1977), and its variability and suitability to texts of different linguistics nature (Brown, 1983). Furthermore, the Cloze Test measures difficulty of the text itself and not the difficulty of the questions (Harrison, 1984). Other studies suggested that Cloze Test reduces the chances of guessing, because filling in the missing words trend help avoid guessing and hence force students to read the text and absorb meanings (Harrison, 1984).

A Cloze Test uses a text with selected words deleted and replaced with underlines of the same length. Having at least 50 blanks in the reading selection

increase the reliability of the test. In this study used 25 blanks were used then multiply by 2. To score a Cloze Test, use the percentage of all the words that are correctly entered, that is, the right words in the right form (no synonyms), number, person, tense, voice, and mode. Do not count spelling.

In this study four passages in different areas of science subject matter on *'Biodiversity'* (p. 307) grade 6, *'People and Erosion'* (p. 344) grade 7, *'Moving Volcanoes'* (p. 168) grade 8, and *'Selection of Peppered Moth(s)'* (p. 225) grade 9, were chosen and it consists of some 196, 171, 174 and 147 words respectively. The topics are new to the students as they have not been taught by the teachers. In all passages, the first and the last sentences were left intact. Deletion of words starts from the second sentence. This was done by counting from the first word of that sentence and every fifth word was deleted henceforth. The deleted words were replaced by blanks of the same length so as not to provide any clues about the size of the words. The respondents were required to supply the correct words, either exact or equivalent words, for the (23 blanks – grade 6), (27 blanks – grade 7), (25 blanks – grade 8), and (22 blanks – grade 9) in the passage. Thus, a maximum total score of 23 for grade 6, 27 for grade 7, 25 for grade 8, and 22 for grade 9 may be scored by students. Percentages of correct answers were generated to establish reading levels of students as suggested by Wellington & Osborne (2001). In order to do this, they need to be able to follow the language pattern and vocabulary to fill the blanks. Students were given 15 minutes to fill in the blanks. The tests were administered in the end of the science lessons and it re-visited after two weeks with the same sample of participants to estimate the reliability, and to calculate the correlation between the two sets of scores.

3.4 Data Collection Procedures

Two experienced science educators; (a science teacher and a researcher) independently analyzed the four matter units of science textbooks for each grades using the same procedure, which involved classifying and matching the elements of the four Scientific Literacy themes with the complete paragraphs, review questions, figures with captions, and tables with captions, charts with captions, and marginal comments. Each science textbook for each grade was read and each unit of analysis was identified and placed into one of the four themes of the Scientific Literacy. Then, the percentages of the four themes were obtained for four matter units of science textbooks for each grade. After the two science educators independently analyzed the four matter units of science textbooks for each grade, they came together to discuss their coding. In cases where there was mismatch between them, they resolved the difference by either adopting one category, or redoing the analysis together.

For the readability of the textbooks, eight passages were randomly selected by volunteer teachers and the researcher, and then randomly selected four passages out of the eight. In this case, the analyses involved counting the number of sentences as well as syllables in each of the four 100-word passages. The following table 3 provides a summary statistics of the selected topics:

Table 3 Summary Statistics for the Selected Topics

Grade level	Topics	Page num.
6	Biodiversity	307
7	People and Erosion	344
8	Moving Volcanoes	168
9	Selection of Peppered Moth(s)	225

3.5 Data Analysis

This study employed mainly quantitative data analyses. Therefore, the analysis of the collected data included the use of descriptive statistics in order to answer the research questions pertaining to the representation of the Scientific Literacy themes of the textbooks as well as their readability levels. Descriptive statistics were also used to profile student actual reading levels so that comparisons between the readability of the science textbooks are compared with the actual reading levels of students.

3.4 Summary

This chapter examined the inclusive description of the procedures used in the implementation of this study. The selected textbooks were used to answer the research questions related to the representation of Scientific Literacy themes and readability levels, which were Science Focus for the United Arab Emirates. The study involved 200 students. The analysis of the textual information to identify the level of representation of the Scientific Literacy themes was based on a framework.

The procedure in this study provided a framework, which involved two methods for examining the use of the readability of the science textbooks by using: the Flesch-

Kincaid Grade Level Readability Formula and the Fry Graph. On the other hand, the actual reading ability of the participating students was determined by the Cloze Test.

This study mainly used quantitative data analyses and the analysis of the collected data included the use of descriptive statistics to answer the research questions.

Chapter 4: Findings

4.1 Introduction

This chapter presents the findings of the current study, which was designed to investigate the analysis of grade (6—9) science textbooks used in ADEC schools in relation to Scientific Literacy and readability level. The current study was designed to address the following main questions:

1. How do science textbooks used in grades 6 - 9 of Abu Dhabi Education Council schools (ADEC) represent the themes of Scientific Literacy?
2. What are the readability indices of science textbooks used in grades 6 - 9 of Abu Dhabi Education Council schools (ADEC)?
3. How are the readability indices of these textbooks progress through the grade levels of Abu Dhabi Education Council schools (ADEC)?

These results are organized and displayed in the tables to present quantitative findings in order to address the three research questions.

4.2 Representation of the Aspects of Scientific Literacy

In order to answer the first research question which was related to representation of the aspects of the Scientific Literacy in the textbooks of grades (6 - 9), the collected data were analyzed and tabulated in forms of frequency distributions and percentages for each aspect as shown in the tables below. It should be noted that topics included for the analyses were unit 1 "arranging in elements" for Grade 6, unit 6 "Metals, non-Metals

and Semi-Metals" for grade 7, unit 1 "Atoms and Elements" for grade 8, and finally "Metals and Alloys" for grade 9.

Table 4: Percentage of Scientific Literacy in Cycle2 School Science Textbooks- Grade 6

Grade level	Dimensions of Scientific Literacy			
	As knowledge (%)	*As investigative activities* (%)	*As way of knowing* (%)	*As an Interaction of STS* (%)
Grade 6	77.2	4.0	14.2	4

For grade 6 textbook and as indicated in Table 4, the knowledge of science aspect was heavily represented mounting to 77.2% of the textual information. The rest of the aspects were presented by the remaining percentage of (22.8%), with the aspect of science as a way of knowing as the second category (14.2%). The investigative nature of science and the interaction of science, technology and society were minimally represented as 4.6% and 4.0% respectively.

Table 5: Percentage of Scientific Literacy in Cycle2 School Science Textbooks- Grade 7

Grade level	Dimensions of Scientific Literacy			
	As knowledge (%)	*As investigative activities* (%)	*As way of knowing* (%)	*As an Interaction of STS* (%)
Grade 7	74.8	2.3	18.1	4.8

Grade 7 textbooks showed similar trends to the representations of the aspects of Scientific Literacy of grade 6 textbooks with heavy emphasis on the scientific knowledge. Table 5 showed that the knowledge of science was dominantly represented as (74.8%) and followed by science as a way of knowing aspect as (18.1%), with the

interaction of science, technology and society representing 4.8%. Again the investigative nature of science only minimally represented (2.3%).

Table 6: Percentage of Scientific Literacy in Cycle2 School Science Textbooks- Grade 8

Grade level	Dimensions of Scientific Literacy			
	As knowledge (%)	*As investigative activities* (%)	*As way of knowing* (%)	*As an Interaction of STS* (%)
Grade 8	60.4	8.1	25.5	6.4

Table 6 shows that the selected units of Grade 8 devote a substantial amount of (60.4%) of their content to the aspect knowledge of science while the investigation nature of science cover with a (8.1%). Science as way of knowing theme present with a (25.5%) are more emphasized than the theme of interaction of science, technology and society, which was represented by 6.4% of the content.

Table 7: Percentage of Scientific Literacy in Cycle2 School Science Textbooks- Grade 9

Grade level	Dimensions of Scientific Literacy			
	As knowledge (%)	*As investigative activities* (%)	*As way of knowing* (%)	*As an Interaction of STS* (%)
Grade 9	52.6	4.5	36.8	6.1

The trends of Scientific Literacy representation continue to grade 9. The results that appear in Table 7 showed that most of the scientific content presented in grade 9 textbooks was focusing on the aspect of the scientific knowledge. The theme of the knowledge of science represented 52.6% of the textbook content, with 4.5% of the content devoted to the theme of investigative nature of science. Science as way of

knowing theme on the other hand was represented by 36.8% of the content, while the theme of interaction of science, technology and society was represented by only 6.1%.

Table 8: Representation of Scientific Literacy in Cycle2 School Science Textbooks

	Dimensions of Scientific Literacy			
	As knowledge (%)	*As investigative activities* (%)	*As way of knowing* (%)	*As an Interaction of STS* (%)
Overall	66.3	3.9	23.7	5.3

Table 8 shows the overall representation of the themes of the Scientific Literacy in the analyzed textbooks for the four grades. Inspection of the table 8 shows that science as knowledge is the predominant theme with 66.3% of the scientific content presented in these textbooks was devoted to the scientific knowledge theme. The material devoted to science as a way of investigation was represented by only 3.9% of the content, and the material devoted to science as way of knowing was given 23.7% representation. Finally, the theme of interaction of science, technology and society was also minimally covered in the content of these textbooks (5.3%).

In summary, the overall the results showed that while high percentages of content coverage were based on a theme of the knowledge of science at the beginning of Cycle 2 (Grade 6), there was a tendency of less representation of this theme as we move up the grades (6 - 9). However, the overall results suggested that the representation of the themes were not really balanced. Science as a way of knowing, as investigative activities, and as interacting with science, technology were all neglected in these textbooks.

4.3 Readability of the Science Textbook

With regard to the second research question pertaining to readability indices of science textbooks used in grades 6, 7, 8, and, 9 Flesch-Kincaid and Fry Graph formulas were performed on three randomly selected passages on the same topics (chapter 2) from each textbook for calculation of the readability indices as suggested by the two formulas. Furthermore, a Cloze Test was used to measure the actual reading levels of students in the different grades to classify students as Independent (Unassisted reading), Instructional (Assisted reading), and Frustration levels. The two readability estimation methods (Flesch-Kincaid and Fry Graph formulas) were chosen because they are relatively easy and simple to use and to apply, and have over the years provided reasonable estimates of readability an indication of their validity to provide accurate measures (Wellington & Osborne, 2001).

In his study, both Flesch-Kincaid and Fry Graph formulas were used to compare the results of the readability level over the same textbooks based upon sentence length and syllable count used for sixth grade to ninth grade. Flesch-Kincaid Readability Formula focuses on the average number of syllables per word and words per sentence, while Fry Readability Graph focuses on the average number of syllables and average number of sentences per 100 words.

Table 9 presents the data for Textbook passages grade level, Flesch-Kincaid grade level, Fry Graph grade level, and Average grade level.

Table 9: Comparison of Readability of Science Textbooks Using Two Readability Formulas

Grade Levels	Reading age level		
	Flesch-Kincaid	Fry Graph	Average
6	8.1	8-9	8.05-8.55
7	10.03	9-10	9.52-10.02
8	9.09	10	9.55
9	9.5	10-11	9.75-10.25

According to the Flesch-Kincaid Reading age levels results, seventh grade showed highest reading demand that was around 10.03; three age levels above the reading ability of the students. As well as, sixth grade levels more than two age levels around 8.1 reading age level. Nevertheless, 9.09; the reading ability age levels obtained for eighth grade one age level higher than the accurate reading age level, whereas, ninth grade respectively indicated that the textbooks were little difficult for the students around 9.5; one to half age levels.

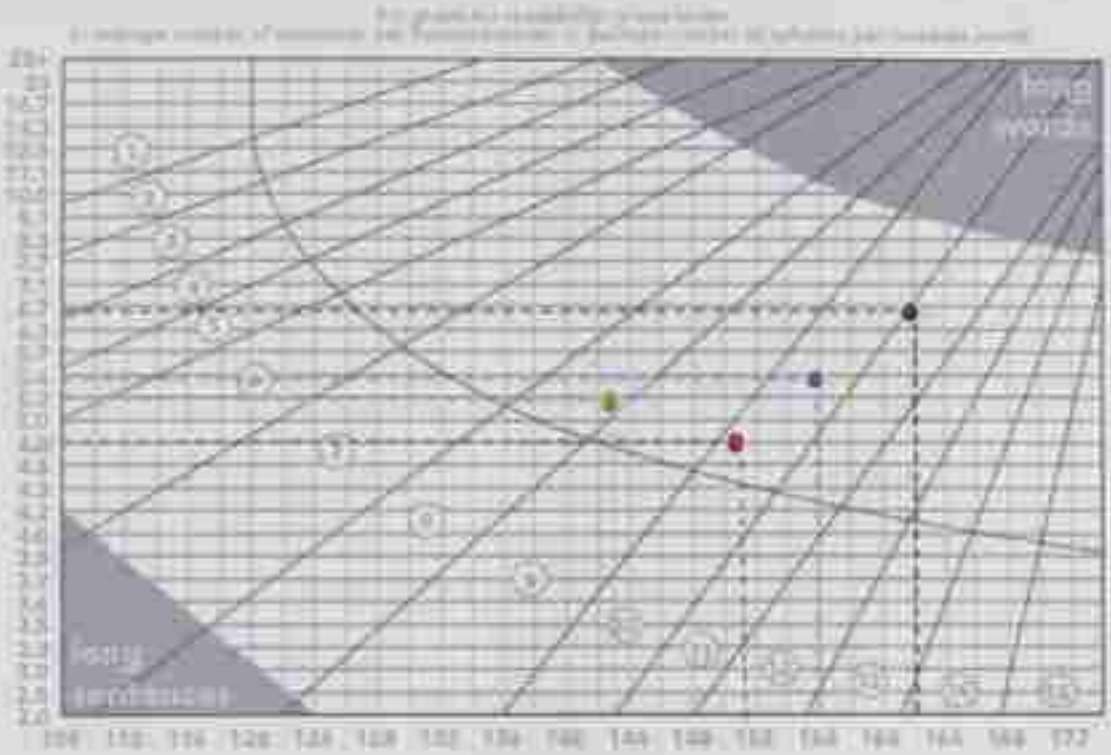
Likewise, Fry Formula showed trends similar to those shown by the Flesch-Kincaid Formula. The highest reading insist that was between 9 to 10 in grade 7 is similar to grade 6 between 8 to 9, which approximately three age levels above the reading ability of the students. Additionally, in both grade 9 and grade 8 the results showed two age levels more than the exact age reading level of the students. Grade 8 results jumped into 10 age reading level yet grade 9 results fostering around 10 to 11age reading levels.

Table 10 shows the average number of sentences per hundred words was in the horizontal axis and for length axis was the average number of syllables per hundred words, this table is explained as can be seen in (Figure 2).

Table 10: Fry Average Number of Syllables and Sentences per 100 Words

Grade level	the average number of syllables per 100 words	the average number of sentences per 100 words
Grade 6	143	5.1
Grade 7	151	4.8
Grade 8	156	5.4
Grade 9	162	6.6

Figure 2: Fry Graph for Readability Grade Levels (Wellington & Osborne, 2001)



- Grade 6:*Average of syllables per 100 words* = ***143*** *Average of sentences per 100 words* = ***5.1***
- Grade 7:*Average of syllables per 100 words* = ***151*** *Average of sentences per 100 words* = ***4.8***
- Grade 8:*Average of syllables per 100 words* = ***156*** *Average of sentences per 100 words* = ***5.4***
- Grade 9:*Average of syllables per 100 words* = ***162*** *Average of sentences per 100 words* = ***6.6***

Seventh and sixth grades involved highest reading insist that were around 8 to 9 age levels above the reading ability of the students. Also, the reading ability age levels

obtained for eighth grade two age levels higher than the exact reading age level while ninth grades respectively indicated that the textbooks were slightly difficult for the students around one age level more. The findings shown in the above graph suggest that all age reading levels around one to one and a half grade level above.

In order to compare the reading levels of these textbooks with the actual reading levels of students, Cloze Tests were administered to a sample of students from each grade level. Table 11 represents the results of the Cloze Test scores at each instructional, independent, and frustration level for the science textbooks.

Table 11: Distribution of all Participate Students at Independent, Instructional, and Frustration Levels

	All Parricipate Students		
Grade level	Independent (unassisted reading) 60-100%	Instructional (Assisted reading) 40-59%	Frustration 0-39%
Grade 6	21.3	22.6	56.1
Grade 7	11.7	16.5	71.8
Grade 8	15.6	38.6	45.8
Grade 9	17.1	35.1	47.8
All	16.4	28.2	55.4

The results showed that only 16.4%of the subjects were able to demonstrate reading abilities at the independent reading level without assistance, while 28.2% of the students in instructional level. At frustration level was sharply more difficult for the students to read so that the result showed a level of 55.4%.

A majority of seventh grade students represented the highest percentage at frustration level by 71.8%. Gradually results found in grade six with 56.1 per cent of the

students at the same level. Furthermore, grade nine and grade eight slightly in the same trends around 47.8% and 45.8% respectively.

Students could read the textbook instructionally level with the assistance of the teachers which clearly less achieving in grade eight with 38.6%, yet students realized 35.1% in grade nine which was gently in high percent. On the other hand, the sixth grade obtained the ratio of 22.6% in the instructional level, even as; the seventh grade was decreased to 16.5%.

Grade six students showed a better result than the rest of the grades where the proportion accounted for 21.3% in independent level. Note through the convergence of results between grade eight and grade nine, where the ninth grade students achieved a higher rate 17.1% than the eighth grade students 15.6% narrowly. Reflected lower ratio has been achieved in the seventh grade, where the result represented 11.7%.

From the findings, it was revealed that all the textbooks are somewhat complex and far above the reading ability levels of the intended readers. It was also recorded that a vast number of the students are reading with frustration. This suggests that the science textbooks presented to all the student levels in Cycle 2 stages are fairly difficult and not appropriate for them. It is therefore recommended that text materials presented to these students should be written with reduced syllable and short sentence length that can be read with ease by the students.

4.4 Progression of Readability Level

The third question deals with the extent to which readability indices of science textbooks progress through the grade levels. In this study, quantitative data emanated from the Cloze Test, and the Flesch-Kincaid and Fry Readability Formulas were used to compare the progression of the readability through the four grade levels.

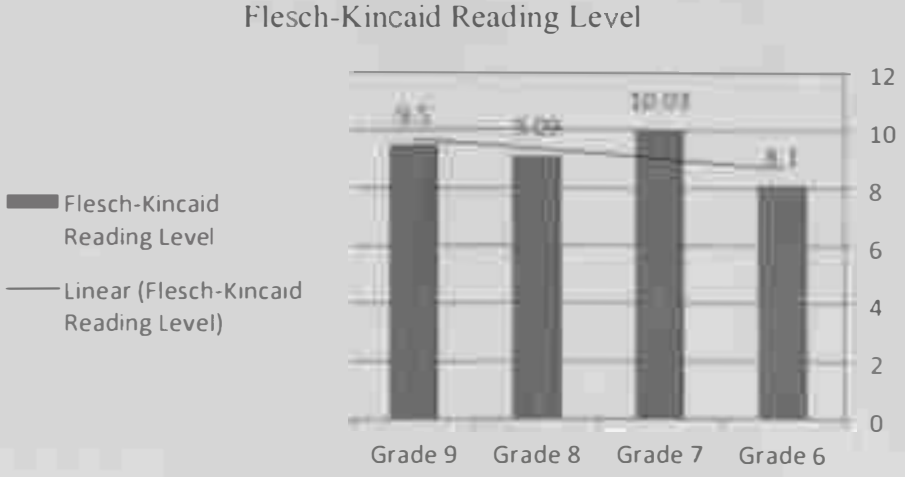
Table 12: Average Reading Age Level of Science Textbooks Using Flesch-Kincaid and Fry Graph Readability Formulas

Grade Levels	Average Reading age level
6	8.05 - 8.55
7	9.52 - 10.02
8	9.55
9	9.75 - 10.25

Based on the enormous quantity of knowledge information contained in science textbooks, Table 12 indicates a significant increase in the level of readability among students in different grade levels. According to the data analysis results, grade 6 and 7 textbooks have matched the reading level of grade 8 -10 to indicate that these textbooks will be too difficult for their corresponding average grade 6 and 7 students. Similarly grad 8 and 9 are matching one grade level higher (grade 9 – 10) than their actual levels.

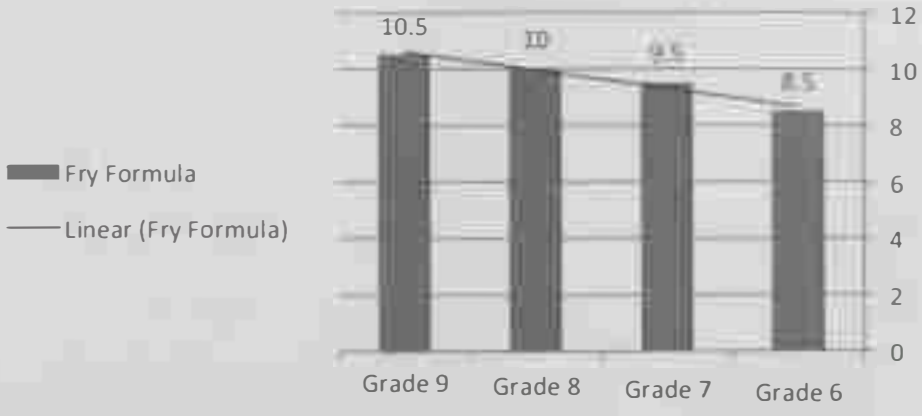
Figure 3, illustrates the progression of Flesch-Kincaid Reading Level in cycle2 grades. It is obviously clear that as student progressed through educational levels, the readability of the textbook of corresponding grade progressed also but at higher rates. Exceptionally, so was the readability index pertaining to grade 7, which was found to be exceptionally higher. It is expected that this trend will negatively affect the progression of the student's reading performance of these science textbooks.

Figure 3: Progress of Flesch-Kincaid Reading Level in Cycle2 Grades



Unlike the trends shown by Flesch-Kincaid formula, a gradual increase was evidenced in Figure 4 for results of Fry reading level. There is a gradual uniform increase in the indices of readability from grade 6 to grade 9; with grade 9 showing the highest level of high readability followed by the 8, 7 and 6 grades.

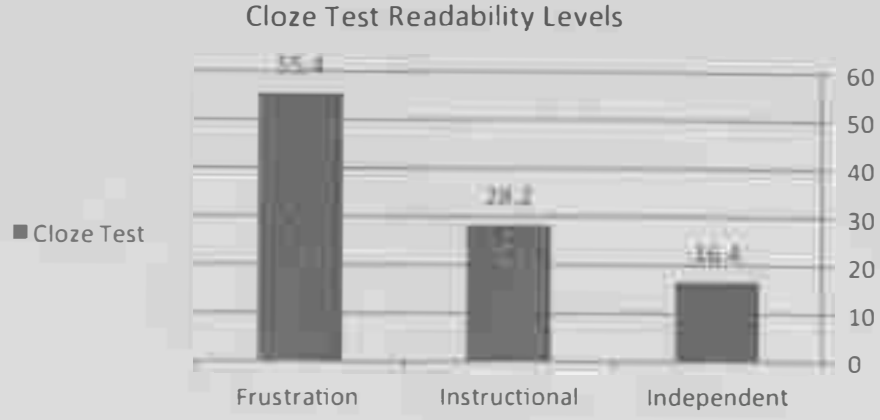
Figure 4: Progress of Fry Reading Level Formula in Cycle2 Grades



Taking into account the findings presented in Table 12 with regard to Cloze, which showed that the majority of student were classified as at the frustration level, it is

obvious that the majority of students will not be able to read these textbooks meaningfully.

Figure 5: Percentage of Student Distribution on the Reading Levels



In summary, the findings from the Cloze Tests and Readability formulae showed that all analyzed textbooks were beyond the reading level of the Cycle 2 grade six, seven, eight, and nine students and as such these textbooks are likely to present challenging information that make them difficult to read with understanding by students.

4.5 Summary

The findings of the study was designed to investigate the analysis grade 6 – 9 science textbooks used in ADEC School in relation of Scientific Literacy and readability level. The results were displayed in the quantitative tables to address three research questions: (1) How do science textbooks used in grades 6-9 of Abu Dhabi Education Council schools (ADEC) represent the themes of Scientific Literacy?, (2) What are the readability indices of science textbooks used in grades 6- 9 of Abu Dhabi Education Council schools (ADEC)? and How are the readability indices of these textbooks progress through the grade levels of Abu Dhabi Education Council schools (ADEC)?

To answer the first research question, the collected data were analyzed and tabulated in forms of frequency distributions and percentages for each Scientific Literacy theme. The result showed as: science as knowledge theme (66.3%), science as a way of investigation (3.9 %), science as way of knowing (23.7%). Finally, the theme of interaction of science, technology and society amounted to (5.3%). The overall results suggested that the representation of the themes were not really balanced. Science as a way of knowing, as investigative activities, and as interacting with science, technology were all neglected in these textbooks.

In his study, both Flesch-Kincaid and Fry Graph formulas were used to compare the results of the readability level over the same textbooks based upon sentence length and syllable count used for sixth grade to ninth grade.

Likewise, Fry Formula showed trends similar to those shown by the Flesch-Kincaid Formula, the highest reading insist that was between 9 to 10 in grade 7,with reading age level (10.03); similar to grade 6 which is approximately three age levels above the reading ability of the students with around (8.1) reading age level. Additionally, in both grade 9 and grade 8 the results show two age levels more than the exact age reading level of the students that paralleled around (9.09) and (9.5).

In order to compare the reading levels of these textbooks with the actual reading levels of students, Cloze Tests were administered to a sample of students from each grade level. The results showed that grade six students had better result than the rest of the grades where the proportion accounted for 21.3% in independent level. The results convergence between grade eight and grade nine, where the ninth grade students achieved a higher rate 17.1% than the eighth grade students 15.6% narrowly. However,

the Reflected lower ratio has been achieved in the seventh grade, where the result represented 11.7%.

Finally, grades 6, 7, and 8 textbooks showed the highest mismatch as high as two grade level above the actual intended reading level. The findings also indicated that Grade 9 textbook was slightly difficult for the students by one age level higher.

Chapter 5: Discussion

5.1 Introduction

The purpose of this study is to examine the nature and extent of Scientific Literacy themes coverage in the science textbooks of the Cycle 2 schools of Abu Dhabi Emirate, and their readability levels in relation to the cognitive readiness of students at Cycle 2 grade levels. The study revealed a number of the important findings presented in the previous chapter were presented in three major sections. The first section presented the findings related to analysis the Scientific Literacy of science textbooks enrolled in grades 6 through 9 in terms of four themes: (a) *the knowledge of science*, (b) *the investigative nature of science*, (c) *science as a way of thinking*, and (d) *the interaction of science, technology, and society*. The second section presented findings related to readability level of science textbooks, which determined by using two instruments namely the Flesch-Kincaid Grade Level Readability Formula, and the Fry Graph. Finally, the third section examined findings related to the reading levels of students as measured by the Cloze Test.

The findings suggested that much of the focus was on introducing science as a body of knowledge and that much of these textbooks can be regarded as beyond the reading level of their intended users- grades 6 – 9.

The purpose of this chapter is to discuss these findings within the context of the literature and identify their implications to the local context. This chapter is divided into three major sections: the first section discusses the findings within the current research findings in science education. The second section presents implications of these findings

for practice and textbook usage. The third section focuses on putting forward recommendations for further research.

5.1.1 Representation of Scientific Literacy

A good curriculum material can be a powerful driving force for improving teaching and learning (Ball & Cohen, 1996). Data analysis suggested that the level of representations of Scientific Literacy differed significantly in the analyzed textbooks. The findings suggested that science textbooks curriculum materials across the four grade levels were found to be focusing on representing science as a scientific knowledge in terms of identifying and explaining concepts, facts, principles, theories and laws, and recalling and transmitting the information. Around three-quarters of science content coverage were based on the theme of science as knowledge especially in grade 6 and 7, with less emphasis on such scientific knowledge at grades 8 and 9.

Furthermore, although, the analyzed science textbooks seem to denote approximately one-third of their scientific content to teaching science through the science as a way of thinking, the four science textbooks have covered only a small percentage of science as an investigative activities, and as an interaction among science, technology, and society.

These findings were in line with previous research studies (Boujouade, 2002; Cakici, 2012; Chiappetta, Fillman & Sethna, 1991; Lorsbach & Moore, 2008; Lumpeand Beck, 1996; Mumba, Chabalengula & Hunter, 2006; Tairab, 2006; & Wilkinson, 1999). These studies reported that the basic knowledge of science aspect of SL is the most emphasized theme followed by science as a way of investigating theme, less on science as a way of knowing, and even less on the interaction of science, technology, and society theme. The findings of the present study seemed to point to the same direction that much

emphasis has been given to scientific knowledge at the expense of the other themes that are much needed today to cope with the demand of the ever changing society.

Cakici (2012) examined the Turkish upper primary level science textbooks and revealed that almost half of the textual material in the science textbooks appears to emphasize science as a body of knowledge. Moreover, Lorsbach & Moore (2008) examined the nature and extent of Scientific Literacy (SL) themes coverage in Zambian national high school biology curriculum and arrived to almost identical findings. Lorsbach and Moore used three data sources, namely, biology textbooks, biology syllabi, and grade twelve national biology examination papers for a five-year period (2000–2004). These data sources were analyzed using the framework and procedure developed by Chiappetta, Fillman, and Sethna (1991). The results showed that the biology textbooks and syllabi content objectives emphasized basic knowledge of science while the biology examination papers and the syllabi objectives emphasized science as a way of knowing. The interaction between science, technology and society theme was the least represented in the biology course. The results also suggest lack of curriculum and instructional validity in biology examinations with respect to the four themes of SL. Several science textbooks have been analyzed to establish the representation of the four themes of SL.

Trends of science textbook analyses often produce similar findings. Abd-El-Khalick (2002) reported on the image of the nature of science found in middle-level science textbooks that are advocated by educators. He used nature of science themes advocated by Chiappetta (1998), and specifically those found in *Benchmarks for Science Literacy* (AAAS, 1993): empirical nature of scientific knowledge, durability and tentativeness of scientific knowledge, replication and confirmation in science, the myth

of the "scientific method" and the imaginative creative NOS, theory-laden nature of science, limitations of science, humanity's contributions to science versus access to the scientific enterprise, and the structure of the scientific enterprise.

Abd-El Khalick concluded that the four books, selected randomly from the National Science Teachers Association list of award-winning science trade books, were devoid of any explicit reference to important elements that define the nature of science. Although these findings were indirectly related to the themes discussed in the present study, they however, reflect the imbalanced views often projected in science textbooks. In order for science textbooks to achieve the purpose for which they are developed and used by students, they need to be carefully written with the view that the themes outlined in the present study are taken care of. Students need to be given opportunities not only to develop scientific knowledge but also scientific thinking and how to carry out investigations.

Erdogan & Kaseoglu (2012), studied 9th grade physics, chemistry and biology curricular that were implemented by the Ministry of Education in Turkey since the academic year 2008-2009, in terms of Scientific Literacy themes and the balance of these themes. They also examine the quality of statements about objectives. They produced findings that are closely related to the current findings of the present study. Their analysis of results revealed that the theme the knowledge of science in the chemistry curriculum and the theme the investigative nature of science in the physics and biology curriculums were well emphasized. However, the theme the science as a way of thinking was not adequately emphasized in each of the three curriculums. The findings of this study suggest that other themes should be more emphasized in science

curriculum to help each of citizens become lifelong learners and have an adequate level of Scientific Literacy.

A context related study conducted by Tairab (2006) with regard to United Arab Emirates science textbooks used in Grade 6 – 9 in Abu Dhabi Cycle 2 schools produced similar findings related to the representation of scientific knowledge Tairab (2006) analyzed Cycle 2 science textbooks for how they present scientific knowledge using a specifically developed framework for characterizing scientific knowledge. The findings showed that the mostly of the curriculum focus across the four grade levels was found to be on representation of science as a scientific knowledge. Science as a way of knowing was the next dominant theme. The scientific content across the four textbooks was presented in this way leaving the other themes to be represented minimally.

Udeani (2013), study results showed the opposite of what came in the current study; the four biology textbooks in Nigeria secondary school were showed that most of the biology textbooks stressed science as a body of knowledge and make an attempt to engage the reader in activities that cause him or her to think, reason and find out which is the theme defined as science as a way of investigating. All the biology textbooks emphasize science as a way of thinking.

Valverde et al. (2002) examined data from 630 mathematics and science textbooks throughout the world that were part of the Third International Mathematics and Science Study (TIMSS) curriculum analysis. They used many characteristics to study textbooks, such as (a) physical features (number of pages and graphics), (b) textbook structure (sequencing content), (c) content presentation (coherence, fragmentation, and complexity), (d) performance expectations (reading, recall of information, answering questions, and engaging in hands-on activities), and (e) lessons

(the text segment devoted to a single main topic). The findings of the research indicated that science textbooks in the United States contain more pages and topics than those in other countries, and also had a larger percentage of fragmented themes.

Wilkinson (1999) states that "if more emphasis is placed on the investigative nature of science, science as a way of thinking, and the interaction of science, technology, and society in [assessment], then we might see a corresponding increase in emphasis given to these areas by teachers and textbook authors" (p. 396). This change may improve students' understandings how science works, their scientific way of thinking for individual and social purposes and, finally, contribute to develop scientifically literate citizens who are ready for the challenges of the 21st century.

5.1.2 Readability of the Science Textbook

Reading science is a key to understand science textbooks content, which can be viewed as having its own language, and, as Piercey (1982) states, "probably the most difficult of all of the languages in the upper grade curriculum are those of the various sciences". In his study, both Flesch-Kincaid and Fry Graph formulas were used to evaluate the results of the readability level over the same science textbooks based upon sentence length and syllable count used for sixth grade to ninth grade. Flesch-Kincaid Readability Formula focuses on the average number of syllables per word and words per sentence, whereas Fry Readability Graph based on the average number of syllables and average number of sentences per 100 words.

According to the Flesch-Kincaid Reading age levels the findings suggested that, 7th grade showed highest reading insisted that was around three age levels above the reading ability of the students. As well as, 6th grade levels more than two age levels reading age level, whereas, 8th and 9th grade respectively indicated that the textbooks were little

difficult for the students around one to half age levels higher than the accurate reading age level. It was cleared that the science textbooks difficult and complicated to read and understand.

The Fry graph was also used to determine the relative difficulty of the vocabulary or sentence length of the passages. The findings obtained by Fry method was above the curve of the graph, it appears that the science textbook has a higher than average vocabulary difficulty. 6^{th} , 7^{th}, and 8^{th} grades involved highest reading ability age levels insist that were around two age level higher than the exact reading age level, while 9^{th} grade results showed that the textbooks were slight difficult for the students around one age levels more. The graph findings suggested that all age reading levels around one to one and a half grade level above. This is an important factor that affects the readability of the textbook.

The Cloze Test was used in this study to determine the Cloze score intervals which are representative of the independent, instructional, and frustrational reading levels and to examine the efficacy of using the Cloze Test to measure reading ability in science textbook. The Cloze Test results indicated that Poorly progress evidently in all grade levels showed in the Cloze Test results, which revealed that the highest numbers of students were mostly at their frustrational reading levels. While, the result dropped in the lowest percentage students at independent level with unassisted reading.

These findings were in line with previous research studies; Yong (2010) attempted to answer the question of "Does the readability of the texts match with the reading ability of the students? "The findings of the readability of the textbook *Secondary Science Book 1* using Gunning, Fry and Flesch-Kincaid formulae, suggested that the

reading level of 14.29 years which was far above the average age of Grade 7 students of 12.3 years old. The textbook used by the students was too advanced and a majority of them likely not be able to comfortably read and easily understand the texts.

The study of Sibanda (2015) examined the readability of two grades 4 Natural Sciences textbooks currently used in South African schools achieved by the use of Cloze and traditional comprehension tests, classic readability formulae, textual analysis and teacher interviews. The major findings of the study were that the two Natural Sciences textbooks used in the study were generally above the reading level of the intended readers, grade 4 learners and that the participating learners did not understand these textbooks. The challenges with the readability of the textbooks stem mainly from the vocabulary and concepts used in the textbooks, which were not well explained. Also, Gecit (2010) showed that the readability of the 9th and 11th grade geography books in Turkey was very low with respect to the Cloze Test, in medium strength with respect to the Flesch-Kincaid test.

El-Masri (2010) outlines an exploratory study involving the readability of the national Year 12 biology textbook in the Lebanese high school system using both Flesch and Cloze Tests, and the reading strategies that students employ when reading science texts. The results showed that the readability of the French version of the textbook was slightly higher than that of its English counterpart according to both Cloze Test results and the Bormuth criteria as applied to the Flesch scores. Furthermore, Olagoke (2012) investigated the readability of basic science and technology textbooks for primary schools used in Ekiti State, Nigeria. Flesch-Kincaid Readability Formula and Cloze Test were used to assess the difficulty index of the Macmillan Basic Science and Technology

for Primary Schools 4, 5 and 6 written by Ogunniyi, M. B. and others. The Flesch-Kincaid formula and Cloze Test indicated that only book 4 is standard and appropriate for the target readers while others textbooks were slightly difficult and not suitable for primary 5 and 6 pupils. It was recommended among other things that long sentences and multi-syllables words of these books should be broken down into smaller components for easy understanding, authors and publishers of the books should write more simplified text materials that can attract readers to their books and thus enhance the comprehension level of the readers.

The findings of Tairab (2006) study showed that the reading age obtained by Flesch-Kincaid and Fry formulae were almost similar for each textbook. The two formulae used suggested that the calculated reading age (13.2 – 16) was much higher than the actual age of students in grades 6 – 9 (which was in the range of 12 - 15). This suggests that the Science Focus textbooks suggested for grades 6 – 9 have reading levels higher than that of students by at least a chronological year, so many of students could find it difficult to read these textbooks in order to reach acceptable levels of understanding of concepts presented in these textbooks.

These findings of this study seem not to support recent national educational reforms stated by curriculum authorities of UAE. At the heart of recent UAE education reforms is the goal to develop students with strong problem-solving and analytical abilities and to equip them with the skills that they need to succeed in their higher education and future careers (ADEC, 2010). In the absence of such consideration of science as a way of understanding the world through the application of inquiry abilities and analytical thinking skills, development of Scientific Literacy as integrated themes such as those reflecting the UAE education reform would be greatly affected. As such learners' ability

to practice science as it reflects the nature of science and scientific inquiry would also be limited. Students need to be equipped with the tools to understand their world so that they become independent thinkers with the ability to create, innovate, and support the economic and social progression of the country (ADEC, 2010). These tools can only be developed from practicing science as scientists do through inductive and deductive activities and understanding of the role of evidence in knowledge construction (Bybee & McCrae, 2011). Clearly, there is a mismatch between students' reading level and readability of the science textbook. One way teachers can help this group of students is to rewrite the texts to make them easier and more understandable but comparable in content without compromising on the science concepts that students need to learn and grasp.

As both the teachers and the students rely to a large extent on the materials and content presented in textbooks as they are specifically written to achieve the stated goals of the UAE curriculum, it will be inappropriate according to these findings to assume that students will benefit from these textbooks. The role of language in concept development was clearly established in the literature and that students need to use language more as interpretative approach rather than simply use it to memorize concepts (Sutton, 1998). In this context reading with understanding is critical to develop scientific concepts, and thus, the importance of selecting and using the right textbooks could not be underestimated.

5.2 Implications for Practice

The results showed that the four themes of SL were disproportionately covered among the science textbooks. The basic knowledge of science and investigative nature

of science received more coverage in science textbooks. On the other hand, science as a way of knowing, and investigative nature of science, and the interaction of science, technology and society themes were the least covered themes across the science textbooks. Consequently, the study highlights the need for paying close attention to how to deliver high quality and scientifically contents of science textbooks for students that includes balanced views of the four themes of Scientific Literacy and at the same time within the reading levels of the majority of students.

Based on these findings and those reported in previous studies, and the efforts of ADEC's developers in supporting the advocated science education reform over the years in the United Arab Emirates, to promote inquiry-based science and updating science textbooks content, it seems that much is needed to achieve these reforms. The study suggests that the developers should focus more on helping science teachers to use the textbooks as resource to enhance the view of science as investigative activities and to learn about the nature of science. Science teachers can gain a great deal by more custom tailored and informed professional development activities about the content and of science textbooks, and how to amplify and supplement these thick resources to engage students in learning about science meaningfully. Curriculum developers must expand science education reform efforts by beginning with what teachers do and use to help students use and consequently learn from science textbooks.

Furthermore, the authors of science teaching materials should be encouraged to develop curriculum materials which address the four themes of SL in order to promote full SL among Cycle 2 school students. Textbook authors should be also, well-versed in the subjects for which they write and knowledgeable about the context of use, and write

a text that is accessible to the learners. Textbooks should not only be challenging but they should also not frustrate to students.

As a consequence, it is necessary to pay attention to appropriateness of the textbooks for student levels while writing science textbooks and this appropriateness should be checked with current texts or those to be developed. In this context, the science books should be written by authors with a reasonable command of readability formulas and a good knowledge of structure and characteristics of UAE reforms that emphasize science as an investigative activities as well as an enterprise that impacts the society.

Furthermore, seeing that the teachers who mediate the textbook information to the students are important stakeholders, the suggestion that all science teachers should be trained to evaluate the suitability and reading ability of science textbooks as part of their teaching responsibilities. Because, where teachers see that the textbooks are beyond their students' reading levels, they need to devise strategies for mediating the content and adapting some of the material and even having the knowledge to dispense with those parts of the texts that will only serve to frustrate the students.

Today, textbooks are no longer single entities available to teachers. Especially in areas with large textbook adoptions, there is a wide variety of ancillary materials marketed with the textbooks. Laboratory manuals, videos, CD-ROMs and other technology, test preparation materials, test generators, transparencies, and related online material are just some of the items that publishers package with their textbooks. Regardless of the other materials that publishers may include with their textbooks, it is

the textbook itself that is a direct and concrete reflection of how that publisher and author choose to represent the nature of science.

The most important issue is giving greater prominence to science technology and society in the school science curriculum. The key aim behind these is to ensure the development of a broad-based science curriculum, and formulate the science curriculum as embedded of the socio-technology and cultural contexts. This means that students will engage with different view points on issues concerning the impact of science and technology on everyday life. They will also understand the relevance of scientific discoveries, rather than just concentrate on learning scientific facts and theories that seemed distant from their realities. Also, there are a variety of ways in which science, technology and society can be approached in the classroom. This offers teachers a degree of flexibility, not only in the incorporation of science, technology, and society perspectives into their science teaching, but also in integrating other curricular areas such as history, geography, social studies and language.

Findings of the present study suggests that the readability of science textbooks is an important factor that affects students' success and understanding of the texts, and which directly has an impact on their performance in science. As the readability of the science textbooks is found to be 2 years higher than the average age of the students, it is very doubtful that many students will be able to extract essential meanings from these textbooks. Moreover, many students will also become discouraged by the textbooks, which they find difficult to read fluently and understand. As a textbook has been defined as a book that no one would read unless they had to by Johnson & Johnson, (2009) it is likely that many students will not be motivated to read the science textbook provided.

It is apparent that students face two major barriers when learning science: the readability of the textbook materials; and their reading ability. The main ways in which teachers can help alleviate these problems are; teachers should attempt to rewrite the texts so that the notes given to the students will be more readable and comprehensible to them. The textbooks should be written in short sentences and contain less difficult words and vocabulary. Furthermore, they should explain the difficult words and vocabulary found in the textbook to the students before the lesson so that the texts will be more intelligible and meaningful to them as they attempt to read them. These should be written on the board so that students can copy and write them down in their note books for reference.

The ability to read and to understand what is written is critical to success in educational system. Moreover, comprehension problems become more apparent when students are faced with reading science textbook materials. More importantly, the students lacked reading abilities due to the vast amount of knowledge, the weakness of acquiring necessary reading strategies, and the absence of a link between scientific knowledge and actual student life results in reluctance to face reading challenges. Teachers who are more effective at supporting students are able to show improvements in student learning in science, making the science real, relevant and rigorous, and building motivational learning strategies can help to be more successful readable students.

According to the Cloze Test, the Fry Graph, and Flesch-Kincaid formula, which were used to consider the appropriateness of textual information in the science textbooks

to student age level, the science textbooks are seen to be generally above the targeted student age level.

This situation makes it necessary to develop alternative approaches to assessing readability levels of textbooks. Since most of the applied formulae are developed on the basis of word and sentence lengths only, they may not adequately and appropriately reflect the textual density of science textbooks. Furthermore, these alternative approaches should also take into account the words cited in textbooks that are not known by the students.

These considerations, if implemented may improve students' understanding of textual information presented in these textbooks, and thus contribute to achievement of curriculum goals that ultimately contribute to the development of scientifically literate citizens who are ready for the challenges of the 21st century.

5.3 Recommendations for Future Research

Although the study provided answers to the research questions set at the beginning of this study, together with the limitations inherent in this study, it become necessary to suggest areas for further research. The need for larger studies with increased science textbooks and participants seem to be an important task. The data from more extensive investigations might lead to an increase in statistical significance and provide a broader generalization of results. Consequently, the helpful of the future research could lead to enriching the field of analyzing science textbooks within the framework Scientific Literacy and readability analyses. Specifically the present study formulates the following suggestions:

1. Investigate whether science teachers understand what constitutes a Scientific Literacy. It is important to document science teachers' understanding of the Scientific Literacy so as to make sure that they communicate scientific information correctly and appropriately to students.
2. Studies on how science teachers can explicitly highlight the relationship between science, technology and society would lead to a realization that science is more than simply scientific knowledge.
3. Further research is needed to study the effect of unbalanced presentation of Scientific Literacy in science textbooks on the students' performance particularly in context where textbooks are used as the only main source of information.
4. Comparative studies should be conducted between Cycle 2 and Cycle 3 science textbooks in the sequences of topics' subjects and the content of Scientific Literacy themes to ensure that these textbooks are within the students' reading abilities.
5. Investigate the influence of textual difficulty in science textbooks on the students of different levels of reading achievement.
6. Examine the differences of reading ability with regard to students' gender across the same topics of the science textbooks.

5.4 Summary and Conclusion

The study was designed to investigate the analysis grade 6 – 9 science textbooks (Science Focus) in relation of Scientific Literacy and Readability level enrolled in ADEC schools. The data were presented in three major sections; first the findings related to analysis the Scientific Literacy of science textbooks enrolled in grades 6 through 9, which in terms of four themes: (a) *the knowledge of science,* (b) *the*

investigative nature of science, (c) *science as a way of thinking*, and (d) *the interaction of science, technology, and society*. The results showed that high percentages of content coverage were based on a theme of the knowledge of science at the beginning of Cycle 2. However, the results suggested that the representation of the themes were not really balanced. In these textbooks science as a way of knowing, as investigative activities, and as interacting with science, technology minimally represented.

Second, the data from readability level of science textbooks determined by using two instruments namely the Flesch-Kincaid Grade Level Readability Formula, and the Fry Graph. From the findings, all the textbooks were somewhat complex and far above the reading ability levels of the intended readers. This suggests that the science textbooks presented to all the students in Cycle 2 stages are fairly difficult and not appropriate for them. Finally, data related to the reading levels of students examined throughout the Cloze Test, which involve three main, indicated the independent level (the material is too easy), the instructional level (the material is about right), and the frustration level from (the material is too difficult). The findings from the Cloze Test and readability formulae showed that all books were beyond the reading level of the Cycle 2 with four different science textbooks worse level of students' readability progression.

The recommendation that authors and teachers had the responsibility to improve the level of science textbooks readability by written science textbooks with a reasonable command on readability formulas and a good knowledge of structure and characteristics of UAE society. While the science teachers played main role on achieve students' reading abilities by using different effective strategies. On the other hand, it was necessary to develop new formulas for readability levels of texts. Future research draw the complete useful image of the study when add more research and investigation upon

the Scientific Literacy and readability to help students to be able to face the UAE future challenges and have a strong basic ability to read science textbooks.

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Appendices

Appendix A: Texts' Topic in Grade (6 - 9):

Grade 6:

Chapter	Topic	Page
Matter	Water Supply	98
Physical World	Introducing friction	113
Living World	Plant pathways	275
Earth & Space	The crust	312

Text 1: Water Supply P: 98

You may be surprised to learn that rainwater is a mixture, and is by no means a pure substance. Rain is produced when water evaporates from oceans, lakes and other bodies of water and even from plants and soil, because it has been in contact with substances that dissolve in it, rain water is a dilute mixture that must be treated before being supplied to our homes.

The rain water that we normally drink has passed through an extensive water supply system, however, and must be treated to ensure it does not contain harmful levels of chemicals or bacteria. Treatment may involve the dissolving of the following substances in the supply.

Text 2: Introducing friction P: 113

Friction is a force between two sliding or rolling objects that acts to slow the object down. A bike will come to a stop if it is not peddled; your school bus will stop if the driver turns the engine off. In these two cases the force of friction will be greater than the force trying to keep the object moving-that is, the unbalanced force will cause the bike or bus to slow down and eventually stop.

Friction is the force caused by the roughness of surfaces and always acts in the opposite direction to the object's movement. Some surfaces have a lot of friction because they are very rough.

Text 3: Plant pathways P: 273

In plants there are two types of transport tubes, which start in the roots and travel up the stem to the leaves. The roots anchor the plant and absorb water and nutrients from the soil. The xylem tubes in the roots carry water and minerals such as phosphorus, nitrogen, sulfur, calcium, iron and magnesium from the soil. Xylem tubes are made of dead calls strengthened with a woody substance. Unlike an animal, a plant does not have a heart to pump liquid through it's tubes-instead, pressure in the roots pushes water upwards. Evaporation through tiny holes in the leaves (called stomata) further assists the flow by sucking water upwards.

Text 4: The crust P: 312

The crust is the layer of Earth on which we live. It contains the land and seas. If we were to dig down into the crust the first thing we would come across is a thin layer of soil and sand. This is followed by a layer composed mostly of soil rock. Just like the shell of an egg, it is brittle and can easily break. On Earth there are 12 major 'pieces' or plates. The crust is thickest under the continents (about 70 km thick) and thinnest under the sea (about 11 km thick). The crust is extremely thin when compared to the diameter of the Earth-like a postage stamp stuck on a basketball.

Grade 7:

Chapter	Topic	Page
Matter	Atoms are mainly empty space	76
Physical World	Carpet static	117
Living World	Introducing digestion	156
Earth & Space	The importance of the sun	200

Text 1: Atoms are mainly empty space P: 76

Working with two other scientists, Geiger and Marsden, Ernest Rutherford experimented with firing tiny positively charged particles (called alpha particles) at thin gold foil. Amazingly, many of the alpha particles went straight through the gold foil, some not even moving from their path. This suggested to Rutherford that most of an atom was empty space, allowing the alpha particles to go straight through. Some of the alpha particles were scattered, however, and Rutherford suggested that this was because they were repelled by a concentration of positive charges in the center of an atom. In 1911 he presented his theory of the atom as consisting of a small, dense positively charged nucleus with negatively charged electrons orbiting the nucleus.

Text 2: Carpet static P: 117

Static electricity often "zaps" you after you have walked on a carpet. Walking rubs your shoes against the carpet sometimes, causing a build-up of charge on your body. Rubber soles may prevent charge leaving via your feet, so that when you touch another object, all that excess charge may jump into the object. This causes a spark and gives you a small electric shock. Change tends to concentrate on sharp corners and spreads out more over flatter surfaces, so one way of avoiding a shock when touching an object that has built up change is to first touch it with an open palm instead of a finger. This spreads the movement of charge and avoids a spark.

Text 3: Introducing digestion P: 156

Digestion is the process in which nutrients and energy are extracted from the food we eat. It occurs in a six to seven meter tube called the alimentary canal, digestive tract or sometimes simply the gut, which runs from the mouth to the anus where waste is expelled. Along the way, food is broken down into smaller, simpler substances that are able to pass into the bloodstream and travel to various parts of our body where they can

dissolve in the water within the cells. It takes food about 24 hours to pass through the entire length of the alimentary canal.

Text 4: The importance of the sun P: 200

The Sun, also known in astronomy as Sol, is our nearest star and is currently in 'middle age', being about 4.5 billion years old, with another 4.5 billion years of 'life' left. Astronomers believe that the Sun is a second-generation star formed after a previous star collapsed, its debris combining with interstellar gas to form the Sun.

The Sun is our source of heat and light energy and so is crucial to the continuation of the life on Earth. Plants use energy from the Sun to help them make the food they need for growth, and in the process make oxygen. Animals that feed on plants, and animals that feed on those animals, also depend on the Sun.

Grade 8:

Chapter	Topic	Page
Matter	Electron shells	70
Physical World	The resistance	89
Living World	Asexual reproduction	111
Earth & Space	Fossils	321

Text 1: Electron shells P: 70

Electrons do not orbit just anywhere around the atom, but in shells or energy levels, which are numbered 1, 2, 3 and 4.

It is easy to picture these shells if we imagine a pea as the nucleus of our atom. The pea sits in the middle of a table tennis ball (our first shell). All this sits inside a tennis ball (second shell), which sits inside a basketball (third shell), which sits inside a beach ball (fourth shell). Imagine electrons as ants on the outside of each ball. Each ant stays as far away as possible from the other ants (electrons repel each other because of their negative charges). Only two ants fit on the first ball (otherwise they would be too close) but more ant-electrons can fit onto the next three balls because those balls are bigger.

Text 2: The resistance P: 89

Electrons have much more differently getting through the thin tungsten filament of a light globe than they do getting through the much thicker and highly conductive copper wire. The electrons give up a lot of energy trying to get through the filament, this energy being turned into heat and light. A globe is an example of resistance something that restricts the flow of charge and 'robe' moving charges of energy. Resistance converts electrical energy into heat and light energy.

Devices such as electric kettles, toasters, irons, and electric hotplates are all simple electric circuits that contain a resistance wire made from the metal Nichrome. Nichrome has much greater resistance than the copper wire used in the rest of the circuit, and so it heats up when a current passes through it.

Text 3: Asexual reproduction P: 111

Asexual reproduction requires only one individual organism or parent. Although this might seem strange, it is happening right now within your own body! All body cells

reproduce in this way, during growth or to repair damage. Many plants reproduce this way too.

In asexual reproduction, there is no need for two types of sex cells. Instead, new cells are formed by older ones called parent cells splitting to make two identical copies, called daughter cells. Because the new organism is made from cells from only one parent, little variation is introduced into the new organism. Organisms produced this way are sometimes called clones. Clones may not always look exactly the same for example, two cloned tree may look different because of the environment they live in.

Text 4: Fossils P: 321

Paleontologists study fossils to add to our knowledge of Earth's history. A fossil is evidence of part of life found in a rock or other material. This evidence may be the remains of a plant or animal, or an impression such as a footprint. In rare cases, a complete animal may be preserved for example, an insect trapped in amber (sap from a plant), or a woolly mammoth preserved in frozen Siberian soil. Fossils can be created when the remains of an animal or plant are covered by sediments (dust, sand or mud) and become part of the sedimentary rock that is formed. Most remains are crushed or decay too quickly for them to be preserved. Sometimes, however, they are preserved as shells or skeletons, as moulds, or as quartz, limestone or even opal 'models' of them.

Grade 9:

Chapter	Topic	Page
Matter	Multiple bonds	89
Physical World	Nuclear accidents	288
Living World	Behavioral adaptation	293
Earth & Space	Birth of a star	316

Text 1: Multiple bonds P: 89

Before we go any further, it is important that you understand the difference between single bonds, double bonds and triple bonds. Some information to help you understand the bonds:

- A single bond is one pair of electrons being shared between two atoms.
- A double bond is two pairs of electrons being shared between two atoms.
- A triple bond is—you guessed it—three pairs of electrons being shared between two atoms.

Carbon has atomic number 6, which means it contains six protons and six electrons. It has two electrons in the first shell, and four electrons in its outer (valence) shell, giving it an electronic configuration of 2, 4. Its four valence electrons place it in Group IV of the Periodic Table. To achieve a stable eight valence electrons, carbon needs to gain four more electrons. It does so by forming four covalent bonds.

Text 2: Nuclear accidents P: 288

There have been several well documented accidents at nuclear power plants in which radiation has been released into the environment. The most dramatic occurred at Chernobyl in the Ukraine (then part of USSR, now an independent country) on 25 April 1986. Automatic safety system were turned off during a test of reactor number4, to measure the turbine's power output as it slowed after its steam supply had been shut off. When power levels fell dangerously low, engineers withdrew most of the control rods. Fuel rods then heated up and turned the moderator water into steam. The steam absorbed fewer neutrons. Causing a power surge that heated the fuel rods even more.

Text 3: Divergent evolution P: 293

The Galapagos Island finches and the geographically isolated rabbits illustrate the idea that many new forms can evolve from a single ancestor. This is known as divergent evolution. The idea is that new environments are inhabited, causing the evolution of new species. Divergent evolution results in a phenomenon known as adaptive radiation. As the ancestral organisms adapt and evolve in their different environments, they take on new forms. The various pent dactyl limbs shown in Figure 8.3.10 in the next unit are an

example of adaptive radiation. Marsupial ancestors have evolved and radiated into many different forms, from tree-dwelling, fruit-eating possums to blind, meat-eating underground moles, and the more familiar kangaroos and koalas.

Text 4: Birth of a star P: 316

Stars are born in a dense cloud of gas and dust found in the spiral arms of galaxies. The raw ingredients of a star are called a **nebula**. The star actually forms when dense regions in these clouds collapse under their own gravity. The nebula's gas and dust come closer together, forming a **protester**. As more material is packed into the protester, the center gets hotter and hotter until conditions are suitable for nuclear reactions to begin. In these reactions, atoms of hydrogen are fused together to form helium, with vast amounts of heat and light energy given out. At this stage, a **main sequence star**, like our Sun, is formed.

Appendix B: Cloze Test for Grade (6 - 9):

Grade 6: Test on understanding of Biodiversity

Instruction:

Please complete the sentences below by inserting the missing words in the space provided. This test does not require you to memorize certain words. It rather assesses your understanding of the sentences below. Your performance in this test does not affect your performance in science and your school grades.

***Time*: 15 min**

First:

Please fill in the following information:

Student Name: _____ **Grade level:** 6

Age: _____ years **Gender :** Male ☐ Female ☐

Second:

Please complete the sentences below:

Biodiversity refers to the number of different species present in a community. Communities with high biodiversity, _____there are many different _____of plants and animals _____together, survive environmental changes _____than communities with low_____, where there are few. _____are usually many different _____ of food in a community _____high biodiversity: there are _____ if one food source _____destroyed. The community is more _____and is able to _____changes in the environment more_____.

In the herbivores in community _____on one particular plant _____ for all of their _____ needs, and then there_____ is determined by the fate

_____ that plant. If the plant _____ to be wiped out _____ disease then the herbivores would _____ wiped out too. In_____, the carnivores that ate them _____ be wiped out. If, _____ the other hand, the herbivores have a _____ of plants to choose _____, they can probably survive the _____ of one particular species._____ have reduces the biodiversity of _____ ecosystems by removing the natural _____ and replacing it with _____ specific type of plant, _____ example wheat. As a result, many species are now extinct.

Grade 7: Test on understanding of People and Erosion

Instruction:

Please complete the sentences below by inserting the missing words in the space provided. This test does not require you to memorize certain words. It rather assesses your understanding of the sentences below. Your performance in this test does not affect your performance in science and your school grades.

***Time*: 15 min**

First:

Please fill in the following information:

Student Name: _____ **Grade level:** 7

Age: _____ years **Gender:** ☐ Male ☐ Female

Second:

Please complete the sentences below:

Science has produced many inventions. These need to be _____ and fuelled, often from _____ found in the Earth's crust. _____ have changed the surface of the _____ dramatically, particularly in the _____ 200 years since the Industrial _____. We have physically broken _____ down by mining them, _____ using explosives, and by _____ the earth with roads, houses _____ cities.

Exhaust gases from _____ and factories have added _____ gases to the air. These _____ slowly chemically weather away _____ on mountainsides and the rock _____ for city buildings. Building _____, roads, and their cuttings, _____ and piers in the sea, _____ ploughing on farms all _____ how water and wind _____. Without careful

planning, these _____ can increase the amount of _____ and sand that is _____ away. The roots of trees _____ plant cover help to _____ soil bound together and _____ it less likely to _____ eroded. Drought, overgrazing and forest clearing can remove grass and plant cover, allowing the wind and water to remove the soil.

Grade 8: Test on understanding of Moving Volcanoes

Instruction:

Please complete the sentences below by inserting the missing words in the space provided. This test does not require you to memorize certain words. It rather assesses your understanding of the sentences below. Your performance in this test does not affect your performance in science and your school grades.

***Time*: 15 min**

First:

Please fill in the following information:

Student Name: ..... **Grade level:** 8

Age: ..... years **Gender:** ☐ Male ☐ Female

Second:

Please complete the sentences below:

Volcanoes are usually located at the weak edges of tectonic plates. Some are nowhere near an _____, however: these volcanoes are _____over hot spots or _____. Although there is no _____weakness in the plate above _____, the magma has so much _____ that it can force _____ way through. The islands of _____ lie 3200 km from the _____ plate boundary. Underwater volcanoes _____ over a hot spot, eventually _____ above sea level to _____ islands. All are different _____. In the west is Kauai, the _____ at 5.5 million years. The _____ is the 'big island' of _____ itself, which began building

_____ years ago and is _____ being extended by lava _____ from the continually erupting Mt Kilauea.

_____ the hot spot never changes _____, the plate above does, carrying the _____ to the west. Hawaii is _____ over the hot spot now _____ will eventually move on, _____. An underwater volcano called Loihi is already forming east of Hawaii and will become the newest island in the chain.

Grade9: Test on understanding of Selection of Peppered Moth(s)

Instruction:

Please complete the sentences below by inserting the missing words in the space provided. This test does not require you to memorize certain words. It rather assesses your understanding of the sentences below. Your performance in this test does not affect your performance in science and your school grades.

***Time*: 15 min**

First:

Please fill in the following information:

Student Name: _____ **Grade level:** 9

Age: _____ years **Gender:** ☐ Male ☐ Female

Second:

Please complete the sentences below:

Over the past 150 years, dramatic changes have been seen in the population of peppered moths in England. In the Mid-1800s, scientists_____ that populations of the peppered _____, *Bistonbetularia*, were changing from _____ light-colored (typical) to _____ dark-colored forms (carbonaria). The _____ occurred during the Industrial Revolution,_____coal-burning factories produced a _____ of pollution in the form _____ soot.

When on the soot-_____ trees, the light-colored form _____ the moth was easily seen _____ birds, their main predator. The _____-colored is an inherited _____. Hence, more dark-colored _____ survived to produce dark-_____offspring.

After clean-air _____ were implemented, lichen began _____ re-grow on tree trunks _____ the trees returned to their _____ paler coloring. Moth population _____ many of these areas _____ shifted back towards the light-_____ forms. Natural selection seems to have taken the moths from light to dark and back to light again.

After clean-air _____ were implemented, lichen began _____ re-grow on tree trunks _____ the trees returned to their _____ paler coloring. Moth populations_____ many of these areas _____ shifted back towards the light-_____ forms. Natural selection seems to have taken the moths from light to dark and back to light again.