CULTURAL AND HISTORICAL PERSPECTIVES ON SCIENCE EDUCATION

Science Education in the Arab Gulf States

Visions, Sociocultural Contexts and Challenges

Nasser Mansour and Saeed Al-Shamrani (Eds.)

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Science Education in the Arab Gulf States

Visions, Sociocultural Contexts and Challenges

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Part 3: The Sociocultural Issues of the Science Education in the Arab Gulf States

INTRODUCTION

It is the pleasure of the *Excellence Research Center of Science and Mathematics Education* (ECSME) at *King Saud University* to introduce this book to those who are concerned about science education in the Arab Gulf States. Our administrators and researchers participated in many international science education conferences and events and met science educators from all over the world. Many of them had visited one or more of the Arab Gulf States or had been invited to participate in some projects related to science education; ever more, we hear the same question: How can we learn more about current situation of science education in the Arab Gulf States? This question encouraged us, as the only research center in science and mathematics education in the Arab Gulf States, to take the responsibility support the publishing of this book. We are very delighted to present first book about science education in the Gulf Arab States to the international readers.

Compared to many developed countries, the formal educational systems in the Arab Gulf States are relatively new. However, many science education projects and innovations have been recently initiated in in the Arab Gulf States and we hope this book will be a window to introduce these initiatives and innovations to the international science education community. The Arab Gulf States, as all countries, believe in the importance of science education in the present and the future. They also believe that science education reforms cannot be successful without creating partnerships with science educators in those countries who have had more experience at overcoming challenges.

This introduction explains the main purpose of this book which we intend to be a part of the international science education community to exchange benefits and experiences. We are trying to open another avenue with our colleagues to allow them to understand, communicate, and participate in our science education. This book provides the readers with an extensive background about science education in the Arab Gulf States so that they can easily contribute to our researches and projects. We hope it will fill the shortage of formal resources about science education in the Arab Gulf States.

The editors of the book made a great effort to encourage science educators in the Arab Gulf States to participate in this book. Fortunately, many of them accepted the invitation to contribute as authors of the chapters. We thank the editors of the book: Dr. Nasser Mansour and Dr. Saeed Al-Shamrani and we thank all authors and co-authors of the chapters. Without their efforts, this book would never have existed.

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Fahad Suliman Alshaya
ECSME Director

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As the editors of this book we would like to express the deepest appreciation to the Excellence Research Center of Science and Mathematics Education (ECSME) at King Saud University, Ministry of Education, the Kingdom of Saudi Arabia for supporting this book project. Without this invaluable support this book would not have come to fruition.

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As the editors of this book, we would first of all like to express our sincere gratefulness to our knowledgeable authors and co-authors without whom this book would not have been accomplished. It is their incredible expertise combined with their timely contributions that have facilitated this high quality book to be completed and published on time. We would like to say a heartfelt thanks to Maher Mohammed Alarfaj, Sulaiman M. Al-Balushi, Khalid Alhammad, Khalil Y. Al-Khalili, Asma Al-Mahrouqi, Hiya Almazzroa, Ahmad S. Alshammari, Abdullah K. Ambusaidi, Ros Fisher, Sufian A. Forawi, Aneta Hayes, Nigel Skinner and Alexander W. Wiseman.

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- Professor Saouma BouJaoude, American University in Beirut, Lebanon
- Professor S.L. Romas De Robles, University of Guadalajara, Mexico
- Professor Gerald H. Krockover, Purdue University, USA
- Professor Xiufeng Liu, The State University of New York at Buffalo, USA
- Dr. Ebru Mugaloglu, Bogazici University, Turkey
- Professor Michael Reiss, University College London, UK
- Professor Peter Charles Taylor, Curtin University, Australia

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The editors
Nasser Mansour & Saaed Al-Shamrani

NASSER MANSOUR AND SAEED AL-SHAMRANI

THE CONTEXT OF SCIENCE EDUCATION IN THE ARAB GULF STATES

THE FOCUS OF THE BOOK

The key purpose of this volume is to provide some perspectives on the state of science education in the Gulf and to share experiences with international scholars about the impact of the innovations and reforms implemented in science education in the region. But the book is also intended to present new visions and to make suggestions and recommendations about the contribution of science education to prepare students in the knowledge age. It will introduce the development of science education in the Arab Gulf states and will present a critical analysis of current issues and concerns in educational research in science education. Chapters will cover the social and cultural contexts of science education reforms and innovations in the Arab Gulf states, with special attention to systems and institutions, curriculum and evaluation, teacher professional development and the use of technology in science education.

AN INTRODUCTION

The economic and demographic profiles of the Arab Gulf States – Saudi Arabia, Bahrain, Kuwait, United Arab Emirates, Qatar, and the Sultanate of Oman – vary significantly. Nonetheless, their public education systems have evolved along similar paths, focusing for decades on increasing the number of teachers and making effective investments in “hard infrastructure – schools and, more recently, computers – in hopes of improving their students’ performance” (Barber, Mourshed & Whelan, 2007). What makes the Gulf countries unique, however, is what is described as the “Gulf State Phenomenon”. These countries are characterized by the intersection of strong religious ideology, rapid economic change and developing social infrastructures. As a result of these shared characteristics, the Gulf countries, and the Gulf Cooperation Council (GCC) countries in particular, have invested heavily and almost identically in education reform and innovation to support mainly economic and social development. Because the Gulf countries are relatively new themselves, the rapid development of education at all levels in the Gulf has involved extensive policy borrowing, from Western countries in particular, and has accelerated the interest in this region as an emerging area of study in the literature (see Wiseman & Anderson 2013, pp. 170–171; Aydarova, 2013).

Historically, the purpose of education in Gulf society was to preserve and transmit traditional culture. Nowadays, leaders throughout the GCC view education as a basic component in building their nations and the foundation of economic development and social change in the knowledge age (G-Mrabet, 2012). However, the reform of the educational system in the six Gulf states reflects the basic dilemma that these societies face – how to reconcile the requirements of modernization with their traditional values (Bahgat, 1999). In this respect Bahgat argues that "the educational system in the six Gulf monarchies is still in the process of crossing the gap from a traditional and religious type of schooling to a modern and secular one. Its main contribution is to produce civil servants. It is ill-suited to the emerging realities of the region's growing integration into the global system. There is a need for more openings, acceptance, and tolerance of modern technology and information. This should reduce the region's heavy dependence on expatriates" (p. 131). In this respect, Rogers (2003) argues that, "Every social system has certain qualities that should not be destroyed if the welfare of the system is to be maintained" (p. 412). Rogers suggests that the values, beliefs and attitudes of a particular culture are effective for that culture and should be judged based on their functionality in terms of the people's own specific circumstances and needs. The norms of the outsider or change agent should not be imposed on the user's culture. A study by Aydarova (2013) to examine why nations borrow policy discourses, research on transfer has overlooked the implementation of transferred educational practices, models, or curricula shows that the significant actors' interpretations of the local culture, context, and students' abilities play a central role in modifying, reducing, or substituting the transferred curriculum. This issue of socio-cultural factors in relation to successful implementation of visions or innovations will be discussed in detail in Chapter 9 by Aneta Hayes. She presents a case study in Bahrain to demonstrate how specific socio-cultural factors may impact successful implementation of such reforms but also to challenge the idea of internationalising schools in the Gulf region as a means of educational improvement.

Over the last few years in the Gulf Arab States, international educational innovations, globalization and economic development have had a significant effect on education in general and on science education in particular but these improvements have been mainly in private education. Serious concerns about the performance of students at the international assessments e.g. the Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) have been expressed by governments, educators and researchers which led to concerns over the state of science education in the Arab Gulf states. Rohit Walia (Executive Vice Chairman and Chief Executive Officer of the Alpen Capital Group) says: "The education sector in the GCC is witnessing a period of tremendous growth. Rising population, higher income levels and an increasing awareness of quality education has resulted in a positive outlook for this sector. While a number of challenges like a shortage of skilled teachers, high initial investment and running costs exist for investors, the education sector continues to be an attractive investment option. Although the private school market across the GCC is highly fragmented, it still offers significant opportunities for new investments and ample room for consolidation for existing players" (Ahmad, Vig & Dhingra, 2012, p. 5) The GCC Education Sector report stated, "The International student assessments like Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study have repeatedly ranked public schools operating in the GCC among the lowest in the world. For instance, as per the PISA result of 2009, eight out of ten best performing schools were private schools. The private education institutes set higher standards and have played a key role in the development of the education sector in the GCC. Private schools also impart students with the much-needed English language skills and focus on maintaining the good quality of education by hiring skilled and trained teachers. Further, these schools also emphasize on mathematics and science in their syllabus, which is a requirement for higher education. Thus, they offer students an easier pathway to university-level education" (Ahmad, Vig, & Dhingra, 2012, p. 44).

Educational policymakers in the Gulf respond to low student performance by focusing on teacher quality as a key to educational reform (Aydarova 2012 in Wiseman & Al-bakr,2012); this response brings the global educational agenda for teacher standards and empirical measures of teacher quality to the fore in Gulf states (Wiseman & Al-bakr, 2012). This raises a question (Barber, Mourshed and Whelan, 2007): Is low student performance in Arabian Gulf countries the fault of Gulf teachers? Education systems in the Gulf are routinely criticized because of their low mean student performance on internationally comparative assessments of mathematics and science (Barber, Mourshed & Whelan, 2007). In this respect, Wiseman and Al-bakr (2012, p. 307) argue that there are many factors that need to be considered: "Many characteristics play vital roles in student achievement at the classroom level. Some of these characteristics are related to students' socio-economic status, while others are related to teachers' ability to teach, interact with, and motivate students. The challenge for policymakers and educators, in the Gulf and elsewhere, is to design teacher certification processes that effectively chase the most elusive of goals: teacher quality." Chapter 1, about teacher professional development in Saudi Arabia and Chapter 3, about teacher education in United Arab Emirates discuss these issues in detail.

Evidence summarised in the Impact of Science Education on the GCC Labour Market publication suggests that creating both a competitive and amenable labour market for GCC nationals in the private sector will require a labour strategy focusing on strengthening investment in human capital. Doing this requires a significant investment in science and technology education either formally or informally. The report contextualizes the labour market relative to science education and vice versa in the GCC countries, and summarizes the literature on the topic before turning to the 2007 Trends in International Mathematics and Science Study (TIMSS) data to examine comparatively science education and expectations for university and labour market transitions within and across GCC countries compared to international trends (see Wiseman, & Anderson, 2012; Wiseman, & Anderson, 2013). Measuring the strength of the economic and welfare systems in the Gulf States using income per capita implies that the Gulf countries do very well. However, they exhibit low science and technology (S & T) activity, which seems at odds with the idea that strong S & T is necessary for economic growth and development. This combination of poor S & T inputs and/or resources together with an inadequate economic system as a whole results in the Gulf countries producing poor S&T outputs and performances. This poor S & T output represents the main challenge in Gulf countries and they do invest a lot of money in these areas in order to improve these outcomes (Nour, 2005). Recently, a number of Gulf states have developed their instituted polices and educational visions and infrastructure that support transition from oil and gas economies to knowledge-based economies (BouJaouda & Dagher, 2009). In this respect, Freeman and Soete argue: "The many national interactions (whether public or private) between various institutions dealing with science and technology as well as with higher education, innovation and technology diffusion in the much broader sense, have become known as 'national systems of innovation'. A clear understanding of such national systemic interactions provides an essential bridge when moving from the micro- to the macro-economics of innovation. It is also essential for comprehending fully the growth dynamics of science and technology and the particularly striking way in which such growth dynamics appear to differ across countries" (Freeman & Soete, 1997, p. 291).

Over the last half a century the six member-states of the Gulf Cooperation Council (GCC) have witnessed an incredible transformation of almost all aspects of socio-economic and political life (Bahgat, 1999). All the GCC countries have had visions to improve their education but the key critical point is that the implementation of these visions is based mainly on importing curricula, educational systems and technologies from Western countries but without too much consideration of the differences between Gulf countries' needs and cultures and these Western countries. (Some of these visions are discussed in this book) To achieve these visions, substantial resources have been invested to provide greater educational opportunities; however, developing educational systems that can produce students capable of tending to the needs of a changing society while at the same time preserving traditional Islamic values has been a major challenge (G-Mrabet, 2012). In this respect, Wiseman and Alromi (2007 in Wiseman & Anderson, 2012, p. 609) argue that the institutional context of schooling in GCC countries poses a challenge to the development of national innovation systems because of the dynamic intersection between religious ideologies, economic development and educational infrastructure, which are defining characteristics of the Gulf State Phenomenon. Mansour (2013) argues that science education forms part of a complex dynamic; people's beliefs, knowledge, values and actions shape and are shaped by the structural and cultural features of society and school cultures. "Science education studies argue that we can know nature only through culturally constituted conceptual or epistemological frameworks, enabled and limited by local cultural features such as discursive practices, institutional structures, interests, values, cultural norms, and so on" (Turnbull, 2000 in Mansour, 2013, p. 348).

This lack of consideration of the socio-cultural contexts hinders the development of education in general and science education in particular in Gulf countries. Lemke (2001) posed the question, "What does it mean to take a socio-cultural perspective on science education?" "Essentially," he answered, "it means viewing science, science education, and research into science education as human social activities conducted within institutional and cultural frameworks" (p. 296). Another question posed by Lemke was, "What does it mean to view the objects of our concern as 'social activities'?" For example in Chapter 3, Sufian Forawi explains that in UAE,"the country developed frameworks for all the school subjects including science for grade 12 in an attempt to strategically plan to develop a systematic science education reform. Nevertheless, this movement is facing many obstacles and has not been seen as influential. The frameworks of science seemed sufficient though with a lack of real contextual and cultural connections as they are mostly drawn from Western documents with little or no relevance to the country's culture and heritage. Also, with a lack of follow-up and evaluation of the many educational initiatives, these reforms remain questionable and open to doubt." G-Mrabet (2012) argues that it is imperative that the change agent understands fully his or her own culture in order to understand how he or she may be perceived by the host culture and thus communicate better and avoid some of the misunderstandings that are repeated over and over.

In short, the Arab Gulf states are in a race to become "knowledge economies" and, as a result, they are promoting educational reforms in all disciplines especially in science education, blended learning, pedagogical innovations and curricula adopted from the West. This book provides a collection of studies on the state of science education in the Arabian Gulf where currently there is increased activity and investment in the reform of science education and the science curricula.

THE STRUCTURE OF THE BOOK

The book is organised into three main sections. The first section addresses the current practices and challenges in science education in some of the Arab Gulf states. This section sheds the light on the challenges and problems that hinder or constrain the implementation of innovations in science education. Also, it presents and critically analyses current practices in science education covering issues related to teacher education, the learning environment, learners, assessments, curricula and the use of technology. The second section explores the science educational reforms and innovations that are being implemented in the Arabian Gulf. This section will present experiences and research with using new approaches to teaching and learning in science classrooms in some of the Arab Gulf states. It introduces new approaches to science education that challenge existing thinking about science education and to define new ways forward. The third section discusses the socio-cultural issues that have impacted on shaping and reshaping the science education in the Arabian Gulf. This section will focus on exploring the socio-cultural factors that influence engagement and non-engagement in science education. It also explores how socio-cultural issues and contexts guide the reform of science education in the Arabian Gulf including issues such as curricula, learning environment and teacher education. This section presents various examples of how we can respond to cultural issues (e.g. religion, gender and language) in the science classroom.

Section 1: The Current Practices and Challenges in Science Education in the Arab Gulf States

In Chapter ,1 entitled "Saudi science teacher professional development: trends, practices and future directions", Hiya Almazzroa and Saeed Al-Shamrani provide an overview of the status and challenges of the science teacher professional development in the Kingdom of Saudi Arabia. This chapter consists of three main sections. The first section reviews the characteristics of effective professional development. The second section depicts the status of professional development in Saudi Arabia. The third section attempts to identify the various challenges coming ahead regarding professional development. The chapter proposes recommendations for advancing science teacher professional development in Saudi Arabia.

In Chapter 2, entitled "Science education in the Sultanate of Oman: current status and reform", Abdullah Ambusaidi and Suliaman Al-Balushi provide an overview about the status of science education in the Sultanate of Oman. The chapter presents the current reform, initiatives and development of science education in Oman. The chapter also discusses the results of TIMSS and how it affects the type and the nature of students' assessment in Oman. Finally, the chapter looks at the challenges facing science education in Oman.

In Chapter 3 entitled "Science teacher professional development needs in the United Arab Emirates", Sufian Forawi presents critically the key aspects of science teacher professional development in the UAE, such as teaching excellence, advancing learning, critical thinking and authentic assessment of students. In particular, the chapter envisions a way forward to present the best science training model that develops teacher competencies, and prepares students effectively for the 21st century. The chapter provides examples of effective science teacher professional development using blended research methods, employing an analytical literature review along with the use of questionnaires and interview techniques. It concludes with a science teacher professional development model that is based on the educational and socio-cultural contexts of the UAE and that allows for teacher growth, and consequently, positively impacts student learning.

Section 2: The Reforms and Innovations of Science Education in the Arabian Gulf

In Chapter 4 entitled "Making the Science Class Spacious for Students' Voice", Asma Al-Mahrouqi explores through an empirical case study the quality of the discursive interaction observed in Omani science classes, using Mortimer and Scott's (2003) Authoritative and Dialogic communicative approaches. The chapter explains the different features of each authoritative and dialogic type. It also discusses ways to encourage the teachers to make the class more open to a dialogic discussion among students and teacher.

In Chapter 5 entitled "Science education reform and related cultural issues in Bahrain: A historical move", Khalil Al-Khalili presents an overview of the ongoing science education reform in Bahrain. Document analysis, interviews and textbook review were used. The chapter shows that curriculum development and reform in general and that of science in particular were of focal interest to curriculum specialists in Bahrain, coping with the worldwide trend, especially that of the Western world.

In Chapter 6 entitled "Conceptual framework for re-shaping science education in Saudi Arabia", Khalid Al-Hammad has designed a conceptual framework based on the teaching sequence to address the issue of science education from constructivist and socio-cultural perspectives. The designed teaching sequence was applied to Saudi secondary students and addressed different issues related to traditional and contemporary teaching methods. Al-Hammad argues that the local Saudi social and culture affected students' understanding of scientific concepts which contradict with the scientific perspective. This chapter makes a recommendation for designing new pedagogical strategies that center on a communicative approach. It also recommends that the local social and cultural issues are taken into account in curriculum development.

In Chapter 7 entitled "A cross-national comparison of Information Communication Technology ICT resources and science teachers' professional development in and use of ICT in the Gulf Cooperation Council countries", Alexander Wiseman and Emily Anderson use data from the 2007 Trends in International Mathematics and Science Study (TIMSS) to comparatively analyse the integration of ICT into science education and its impact on student learning among 8th graders in the GCC. They argue that ICT infrastructure considerations in GCC educational systems should be about more than providing technology for students and teachers to use, but extend to the importance of providing infrastructure for building capacity as well. In addition they argue that targeted and strategic use of ICT-based instruction has a significant impact on student learning outcomes.

Section 3: The Sociocultural Issues of the Science Education in The Arabian Gulf

In Chapter 8 entitled "Science Education in Saudi Arabia: A Response to Controversial Issues", Maher Mohammed Alarfaj discusses the moral and ethical awareness in science education in the Kingdom of Saudi Arabia. The chapter discusses the connection between the scientific mind and Islam. The primary focus of this chapter is the imposition of science curricula in Saudi Arabia and science teacher preparation programmes, and how they correspond to social and technological paradigms while incorporating ethical and moral qualities.

The socio-cultural issues that may have an impact on the reforms of science education in Bahrain are tackled by Aneta Hayes in Chapter 9, entitled “Adopting Western models of learning to teaching science as a means of offering a better start at university? The impact of socio-cultural factors: A case of Bahrain”. Hayes doubts whether adopting Western programmes can solve problems with science education in the Gulf Cooperation Council (GCC) countries and proposes that matching reform with the broader societal view might be a better way forward. She draws on the findings from a qualitative case study in Bahrain where secondary science teachers, first year university students and relevant university faculty staff were interviewed in focus groups and semi-structured interviews. Hayes argues that societal culture has a great impact on the functioning of schools and the complexity of factors that influence the way schools teach science. In addition, she argues that the research emphasises that socio-cultural factors are difficult to change and that introducing new reforms should be based on considerations of these factors.

The socio-cultural factors that impact the science education in Oman are critically analysed and discussed by Al-Balushi and Ambusaidi in Chapter10, entitled “Science education research in the Sultanate of Oman: the representation and diversification of socio-cultural factors and contexts”. The authors conducted a survey study with 16 science education researchers. It shows that some research areas in Oman have not had much attention from researchers, such as religious beliefs, non-Arabic spoken languages, age levels, school locations and mixed gender school settings. In this chapter the authors suggest some recommendations to enhance the representation and diversification of socio-cultural factors within science education research in Oman, and in the Gulf Cooperation Council (GCC) states.

In Chapter 11, entitled “The Socio-Cultural Contexts of Science Curriculum Reform in the State of Kuwait”, Ahmad Alshammari, Nasser Mansour and Nigel Skinner present a study that critically evaluates the science curriculum in Kuwait from the perspective of science teachers. This chapter focused on the teachers’ views regarding the extent to which the new science curriculum relates to the Kuwaiti social cultural context and the Islamic religion. Al-Shammari argues that the curriculum content is not much related to Kuwaiti society and culture or the Islamic religion and this has negatively influenced students’ understanding and attitude towards learning science. The chapter makes recommendations regarding teacher professional development and the development of the science curriculum.

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PART 1

THE CURRENT PRACTICES AND CHALLENGES IN SCIENCE EDUCATION IN THE ARAB GULF STATES

HIYA ALMAZROA AND SAEED AL-SHAMRANI

1. SAUDI SCIENCE TEACHER PROFESSIONAL DEVELOPMENT

Trends, Practices and Future Directions

ABSTRACT

Professional development is one significant mechanism for maintaining a high standard in science teaching. This chapter is intended to provide guidance that stems from best practice, as highlighted in the relevant literature and analysis of the state of science education in the country. The chapter consists of three main sections: the first section reviews what has been published over the past decade, which provides a base of knowledge about the characteristics of effective professional development. The second section depicts the status of professional development in Saudi Arabia, and highlights where we have yet to improve. It draws on the available data and efforts surrounding professional development. The third section attempts to identify the various challenges ahead regarding professional development. Based on these three sections, we propose recommendations for the advancement of science teacher professional development in Saudi Arabia.

INTRODUCTION

The Kingdom of Saudi Arabia is investing in a significant opportunity to gain improvements in education. This includes allocated governmental funding for the new science and mathematics curriculum, as well as King Abdullah's project for public school education (Tatweer Project). Science education in Saudi Arabia is receiving more attention than it has ever received before. The government contracted a national company (partnered with an international company) to provide new instructional materials supported by professional development programs for both science supervisors and teachers.

These efforts, essential as they are, need to be accompanied by a more effective and systematic approach to supporting, developing, and mobilising science teachers who will teach in and lead schools. The reform initiatives in science education are causing a shift from conventional teaching styles to more progressive, inquiry-oriented methods. This means that teachers need to be supported regarding how to approach such novel teaching.

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 3–21.

Professional development is one significant mechanism for maintaining a high standard in science teaching. The most important reason for professional development as identified by the American Association for the Advancement of Science (AAAS, 1998) is to help teachers to recognize the special expertise related to their work. Second, Professional Development is essential for teachers to master the knowledge and skills needed as pre-service education is neither long enough nor intense enough. The third reason is to help teachers grow and develop and, finally, to improve teaching quality.

In a centralized education system as in Saudi Arabia, educational authorities are responsible for setting policies and making decisions on the kinds of professional development that will be supported and implemented. In this chapter we intend to provide guidance which stems from best practice, as highlighted in the relevant literature and analysis of the status of science education in the country.

The following pages include three main sections. The first section provides a review of the existing research on effective characteristics of professional development. The second section depicts the state of professional development in Saudi Arabia, through snapshots of how professional development is being designed. The chapter ends with a third section in which we propose future directions for advancing science teachers' professional development in Saudi Arabia. Not least, this chapter is a major first step toward developing a comprehensive set of policies and practices that help to better organize professional development. Our ongoing research, informed by the wider literature on professional development, attempts to develop a framework of professional development that can enrich the practices of science teacher development. Our concern as researchers is to develop a greater understanding of what makes professional development effective.

SIGNIFICANCE OF PROFESSIONAL DEVELOPMENT TO SAUDI CURRICULUM IMPLEMENTATION

What is the best way to reform science education in Saudi Arabia?. Currently, The country is running a new science education reform, In 2009 a new Mathematics and Science Curriculum was launched; an adapted series of science textbooks produced by American publishing company McGraw-Hill was translated and modified to be adopted for all school levels. The new science curriculum emphasizes current teaching and learning trends and promises to adopt a learner-centred approach with inquiry-based instruction (Obeikan, for Research and Development, 2010). But this will only happen if teachers' classroom practices reflect high standards. It appears that teachers do not implement appropriate teaching practices (Alrwathi Almazroa, Alahmed, Scantbly, & Alshaya, 2014). Education reforms will not succeed without teachers who are immersed in the subject they teach and well equipped to implement appropriate teaching practices.

Professional development of teachers plays a key role in the new curriculum implementation and is widely believed to be required in order to support implementation (Richard & Neil, 2011; Spillane & Thompson, 1997). Reforming science education requires much more intensive professional learning than has been available until now. There is a concern in curriculum implementation that teachers will continue with existing traditional teaching practices, with a little tinkering to show that they have modified their teaching towards the specified way (De Beer, 2008). Therefore, Atweh, Bernardo and Balagtas (2008) consider teachers as the principal mediators of curriculum implementation and view professional development as an integral component if curriculum reform is to reach the classroom. We view professional development as a crucial element of the nation's efforts to improve education. Blank and Alas's (2009) meta-analysis study provided evidence of the effects of science and mathematics teachers' professional development on improving student learning. By measuring and summarizing consistent, systematic findings across multiple studies, a positive relationship between student outcomes and key characteristics of the design of professional development programmes was identified.

In Saudi Arabia, professional development has only recently been considered a national priority and a main research priority in the field of science education (Alshamrani, 2012; Obeikan for Research and Development, 2010). So far, much of the professional development that is offered to teachers simply does not meet the demands of the new curriculum (Almazroa, Aloraini, & Alshaye, 2014). However, as Richard Elmore stated in American Federation Of Teachers (AFT), "Unless you have a theory about how to support instructional practice, you don't have a prayer" (AFT, 2008, p. 1).The focus should be on formulating and implementing professional development that makes realizing the reform possible. Since professional development is an essential element of comprehensive reform, it has to be carefully crafted and well designed, otherwise the dream will not be realized. An effective professional development programs requires radical changes in practice. Furthermore, if it is to be understood as learning activities rather than training activities, as Mansour, El-Deghaidy, Aldahmash and Alshamrani (2012) note, it should have a guiding framework that frames all the activities, so professional development leaders can design meaningful learning experiences for all teachers.

Therefore, the Ministry of Education needs to bolster teachers' knowledge and skills and ensure that professional learning is well planned and organized, as improving professional learning for educators is a crucial step in transforming schools. In fact, science teacher professional development all around the world has received special attention among policy-makers (National Research Council, 2009). Today, professional development is a major focus of the reform initiative and has become a necessary expectation in schools. The need for high quality professional development is urgent in light of the many new tenets on which the new curriculum is based. Therefore, understanding the characteristics of effective professional development is an important starting point to provide support for policy-makers and educators. Research is needed to examine what kinds of professional development provide support for the implementation of the new curriculum.

CHARACTERISTICS OF EFFECTIVE PROFESSIONAL DEVELOPMENT FOR SCIENCE TEACHERS

The concept of professional development has changed from a fairly narrow view which regards professional development as a special event that is restricted to a few days with top-down models, to a wider concept defined as "processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students" (Guskey, 2000, p. 16). Beliefs about professional development have changed from in-service programmes, which aim to use outside expertise to increase teachers' knowledge, to a wider spectrum which includes not only teachers but also the organization to which the teacher belongs (Loucks-Horsley, Hewson, Love & Stiles, 1998). Reform models engage teachers in authentic activities within learning communities, connecting professional development to classroom work, and emphasizing inquiry-based instructions (Butler, Lauscher, Jarvis-Selinger & Bechingham, 2004).

Central to efforts to improve the quality of professional development is the provision of research-based evidence of effective characteristics. Research over the last few years has provided a base of knowledge about important qualities pertaining to the design and enactment of professional development. During the last decade there has been an increasing focus on what makes professional development effective. This section summarizes current research, which has been discussed in the domain of general education and more specifically in science education, by experts in the field as well as agencies in education.

Significant contributions are represented in agencies' efforts to provide guidance in developing effective professional development. In the US the National Staff Development Council (NSDC, 2001) outlines standards for staff development to improve all students' learning; these standards are listed in Table 1. Also, to supply evidence on the impact of high-quality teacher professional development, the American Federation of Teachers (AFT, 2011) published principles for professional development, which were derived from teachers' views (see Table 1).

What does research say that works and what needs to be done to develop the best learning opportunities for science teachers? Darling-Hammond, a well-recognized expert in the field, identified essential elements to professional learning that need to be included in pre-service and in-service education (1998, p. 2, see Table 2). Birman, Desimone, Porter and Garet's (2000) research-based study marked an important advance within the field because it relied on a survey of 1000 teachers who participated in a professional development programme, and on case studies, and gave empirical evidence on the relative value of professional development features. They identified three structural features that set the context for professional development – form, duration, and participation – and the core features necessary for the success of those structural features – content focus, active learning, and coherence (see Table 2). Many of the features of professional development which

Table 1. Professional development characteristics as viewed by educational agencies

NSDC (2001)	*AFT (2011)*
Staff development that improves the learning of all students should have the following features: • learning communities, • leadership development, • required resources, • data driven, • uses multiple sources for evaluation, • research-based, • appropriate strategies for the intended goals, • understand equity, • quality teaching, • family involvement.	Professional development should: • deepen and broaden knowledge of content, • provide a strong foundation in the pedagogy of particular disciplines, • provide knowledge about teaching and learning processes, • reflect the best available research, • be aligned with the standards and curriculum that teachers' use, • contribute to a measurable improvement in student achievement, • be intellectually engaging, • provide sufficient time, support, and resources, • be designed by teachers in collaboration with experts in the field, • take a variety of forms, including some we have not typically considered, • be job-embedded and site-specific.

Table 2. Professional development characteristics as viewed by experts

Darling-Hammond (1998)	*Birman, Desimone, Porter and Garet (2000)*
• Professional development avoids generalities and abstractions and deals with everyday teaching and learning practices such as lesson planning and student evaluation. • It is built around real cases and questions. • It builds colleagueship through encouraging professional discourse which leads to analysis and communication about practices and values.	• Reform orientation with reform-oriented activities. • Duration in terms of both time and span and total contact hours. • Collective participation of teachers from the same school. They also identified the core features necessary for the success of those structural features: • *Content* refers to enhancing teachers' discipline knowledge, • *Active learning* encourages teachers to become more engaged in discussion, planning, and practice, • *Coherence* refers to the extent to which professional development experience is part of the integrated programme of teacher learning.

they found to be significant predictors of effectiveness had been already identified in the literature.

As a field, science education has a set of recommendations for fostering professional growth. The National Research Council published a set of professional development standards in 1996 entitled the *National Science Education Standards* (NSES). These include recommendations for teachers of science to learn science content through inquiry, to integrate knowledge of science, learning, and pedagogy, to build understanding as a lifelong learner, and for professional development opportunities to be coherent and integrated (NRC, 1996; see Table 3). Loucks-Horsley et al. (1998, p. 37) described a common vision of effective professional development in science and mathematics. This common vision identifies the seven principles that are listed in Table 3.

Table 3. Professional development characteristics as viewed in science education

NRC (1996)	*Loucks-Horsley et al. (1998)*
• Learn science content through inquiry. • Integrate knowledge of science, learning, and pedagogy. • Build understanding as a lifelong learner. • Professional development opportunities that are coherent and integrated.	• A well-defined image of effective classroom learning and teaching. • Opportunities for teachers to build their knowledge and skills. • Use or model with teachers the strategies they will use with their students. • Build a learning community. • Support teachers to serve in leadership roles. • Provide links to other parts of the education system. • Assess themselves and make improvements to ensure positive impact on teacher effectiveness.

At the local level, reaching a consensus regarding characteristics of effective Saudi professional development is an important starting point to leverage support for policy makers and educators. Almazroa (2013) attempted to provide a conceptual framework for professional development and produced a list of characteristics for professional development that are suitable for the Saudi educational system, by relying not only on the literature, but surveying a sample of Saudi science teachers, five key dimensions were derived for professional development. Table 4 provides an overview of the vision for professional development that includes certain elements of each dimension

Table 4. Effective characteristics of Saudi professional development for science teachers

Professional Development Dimensions	*Effective characteristics*
Goals	1. Share a common vision of teaching and learning. 2. Promote collegiality and collaboration to create learning community for science teachers. 3. Build leadership capacity. 4. Increase teachers' creativity and innovation. 5. Teaching ethics.
Content	6. Deepen teachers' content knowledge. 7. Learn content knowledge through investigation and inquiry. 8. Provide a strong foundation in the pedagogy of the disciplines. 9. Professional development should provide knowledge about the teaching and learning processes. 10. Based on teachers' needs.
Support	11. Must be long-term coherent plans. 12. Provide incentive to ensure motivation and encourage teachers' participation. 13. Provide highly qualified training team. 14. Provide support and mechanisms to enable teachers to master new content and pedagogy and to integrate these into their practice. 15. Require resources to support learning.
Approaches	16. Should take a variety of forms and include a follow-up with teachers. 17. Teachers, who are the practitioners, should be centrally involved in formulating professional development plans in cooperation with experts in the field. 18. Include active methods of teacher learning. 19. Use various technological innovations to learn content and pedagogy.
Evaluation	20. Must be reviewed and assessed to constantly improve the impact of these activities.

A ANALYSIS OF CURRENT PREFESSIONAL DEVELOPMENT IN RELATION TO RECENT TRENDS

Although formal education in Saudi Arabia was founded in the 1930s, attention to teacher professional development programmes was initiated in 1975 under the *General Administration of Teacher Preparation Programs*. In 1981, it came under the *General Administration of the Educational Guidance and Training*. It was not until 1998 that an independent administration for teacher training was launched called the *General Administration for Educational Training and Scholarships*, which was responsible for two types of professional development programmes: teacher training and internal and external scholarships for teachers (Ministry of Education, 2013). Currently, a centre for training and scholarship has been established in each of the 45 educational departments across the entire Kingdom; these centres provide training programmes for all teachers.

Moreover, science and mathematics teachers receive a secondary professional development programme as part of the Project of Mathematics and Natural Sciences (PMNS), the new reform in science and mathematics education, which was launched in 2009. Programmes introduced through PMNS are related to science and mathematics teaching than those programmes introduced by the centres. For example, the centres design and provide professional development programmes to suit any teachers, whereas PMNS professional development is specifically tailored towards science or mathematics teachers. PMNS trains science supervisors to prepare them to train science teachers; however, the centres provide their programmes independently according to a general plan by the general administration.

Although PMNS uses the term ‘professional development programmes’, it utilizes training workshops as the most common source for science teacher professional development. In fact, the term ‘training’ is the most prevalent term mentioned when it comes to educational research in Saudi Arabia. Predominantly, the researchers investigate either the impact of a training programme with regard to some independent variables or the training needs for science teachers (Abulhamail, 1999; Aldalan, 2004; Alfohaid, 1999; Flemban, 2003; Rafa, 1993). However, the *Excellence Research Center of Science and Mathematics Education* (ECSME) at King Saud University conducted a pilot study to identify the research priorities in science education in Saudi Arabia; the study found that research in professional development programmes was the highest research priority in the context of Saudi Arabia (ECSME, 2009). This study was followed by Alshamrani (2012), who aimed to identify the same goal using the Delphi method. Unsurprisingly, this study also found that research in professional development was the first research priority in science education in Saudi Arabia. In 2010, as part of the ECSME’s goals, a research group was initiated to study science and mathematics teacher professional development, and has been conducting important work which reflects the status of science teacher professional development, in addition to what has been carried out by other researchers such as Alshaye (2013).

In this chapter, we attempt to shed some light on the extent to which Saudi science teachers receive the kinds of professional development that the research recommends. Readers should be reminded that researchers for this paper found limited official documentations about professional development. Thus, this section relays heavily on recent research on science teacher professional development in Saudi Arabia. In this section, we identify common findings across studies on the status of professional development in comparison to Saudi effective professional development characteristics listed by Almazroa (2013) as follow:

1. Goals of Professional Development Programmes

As a central education system in Saudi Arabia, the goals of PD programmes established by the Ministry of education through identifying the needed skills and competences of teachers (Sabah, Fayez, Alshamrani, & Mansour, 2013). Mansour et al. (2012) found a mismatch between the perceptions of science teachers and their supervisors regarding their PD needs; they argued that other authorities in the Ministry of Education may have different priorities. Sabah et al. (2013) indicated that the PD programme providers do not participate in defining PD they are providing. Moreover, Mansour, El-Deghaidy, Alshamrani, and Aldahmash (2014) found that the teachers do not also participate in articulating the goals of their received programs. They also indicated that a single provided programme expected to fit all the teachers regardless of their teaching subject, existing knowledge, needs, and school contexts. The lack of the voice of science teachers, supervisors, PD providers, and other related people can minimize the achieved expected outcomes of such these PD programs.

The analysis of the listed programs and guidebooks for training programs in some educational districts in Saudi Arabia indicated that there is a lack of guiding goals for these programs. The lack of these shared goals among the educational district can be attributed to the way of formulating the list of the provided programs. As indicated by the providers of PD programs, forming a list of training programmes starts through prioritizing the needs of science teachers by the Ministry of Education (Sabah et al., 2013). Although we did not find an evidence of an existing list of goals leading PD for the teachers, it might be exist in some ways; yet, what is apparent for us is the lack of enhancement of shared goals on formulating a coherent PD programs for the teachers in the educational districts. However, In King Abdullah's project for public school education (Tatweer Project) which is supposed to contribute to science teacher development, a set of goals are provided for PD; the goals related to science teachers are: improving general education outcomes through developing basic teaching skills, improving learning capacity for both teachers and supervisors, and improving teachers' leaderships of their classrooms (Tatweer Project, 2014). However, no evidence has been provided yet to clarify who to reflect these goals on teacher PD programs.

2. Content of Professional Development Programmes

Alshamrani et al. (2012), Mansour et al. (2013), Alshaye (2013) and EL-Deghaidy et al. (2014) used the voices of science teachers, supervisors and PD programme providers to reveal the content covered in the professional development programmes. These studies concluded that programmes focused on both subject knowledge and pedagogy. However, they reported that pedagogy receives more attention in comparison to subject knowledge. EL-Deghaidy et al. (2014) interviewed science teachers to identify their PD needs and subsequently classified them into four main themes: pedagogical, scientific, Information, Communication Technology (ICT), and professional skills. Table 5 shows these themes and their sub-themes.

Table 5. Professional development needs reported by science teachers (EL-Deghaidy et al., 2014)

Main categories	*Sub-themes*
Pedagogical knowledge	Deepening pedagogical content knowledge
	Responsiveness to the new science curricula reforms
	Classroom management
	Assessment
	Accommodating students' individual differences
Content knowledge	Deepening subject content knowledge
	Practical skills
	Cultural issues related to science education
ICT	Technological pedagogical content knowledge (TPCK)
Professional skills	Self-development and learning how to learn
	Teacher as a researcher
	Leadership

However, this list of themes do not fit with what are actually provided; PD programme providers mentioned that they delivered content such as teaching strategies, classroom management, project based learning, differentiated learning, active learning, inquiry, and constructivism (Sabah et al., 2014). The guidebook for training programmes included a special list for the provided programmes for science and mathematics teachers; this list encompasses: the basic kit, differentiated instruction, active learning, conceptual understanding, planning for understanding (Tabouk Educational Administration, 2014). This list can be found in all educational districts since they are provided by the Ministry of Education. Moreover, science teachers in all districts can receive some general programmes such as assessment and educational technology; however, the main distinction between the list of actual programmes and the reported needs for science teachers are content knowledge and professional skills.

3. *Supports for Professional Development Programmes*

In an evaluation study provided to the Ministry of Education, it was found that the organizational support for PD was low as viewed by 1999 science and mathematics teachers (Almazroa, Aloraini, & Alshaye, 2015). Alshamrani et al. (2012) identified some obstacles related to the supports from either ministry or administration levels that Saudi science teachers face when participating in professional development programmes; the most important included a heavy teaching workload, inappropriate timing of the professional development programme, lack of advertising, the restricted number of available professional development programmes, and the limited incentives to encourage participation in professional development programmes. In another study (EL-Deghaidy et al., 2014), teachers reported factors that may persuade them to participate more in professional development programmes, including receiving financial recognition, attendance certificates, reducing teachers' workload, and consideration of teachers' opinions. They also mentioned some factors related to the programmes such location, timing and duration, and utilizing ICT.

4. *Approaches for Professional Development Programmes*

Almazroa, Aloraini, and Alshaye (2015) surveyed 1999 science and mathematics teachers to evaluate PD programs they are receiving, findings revealed that the most prevalent PD methods were workshops (29.3%), supervisor guidelines (21.3%), teachers' classroom exchange visits (15.6%) and model lesson observations (13.4%), it was found that other methods were not popular and were practiced rarely, including discussion groups (8.6%), meetings and symposia (4.2%), online training (4%) and participation in research (2%). The studies by Alshamrani, Aldahmash, Alqudah and Alroshood (2012) and Alshaye (2013) aimed to identify the status of science teacher professional development programmes in Saudi Arabia. Alshamrani et al. (2012) focused on science teacher programmes from science teachers' and supervisors' perspectives whereas Alshaye focused on science and mathematics teachers from the providers' perspectives. The results of the two studies have many variations and junctions; however, they led to one conclusion: the professional development of science teachers is not benefitting from important sources such as communities of practice, universities, and associations. Science teachers are limited to their official interaction with their supervisors, official training programmes and workshops, official observation exchanges with peers, and personal interest in reading. Sabah et al. (2014) found an absence of school enacted PD such as peer coaching, critical friendships, mentoring, action research, and the community of practice model; and out of school learning such as joining professional development networks, school-university partnerships, conferences. In EL-Deghaidy et al. (2014) study, science teachers talked about official training programmes when it comes to professional development programmes. Howell and Stubbs (1996) asserted that professional development programmes should go beyond the official initiatives. Furthermore, the National Science Education Standards in the United States suggest some techniques for life-long learning:

> Teachers of science develop the skills to analyze their learning needs and styles through self-reflection and active solicitation of feedback from others. They must have the skills to use tools and techniques for self-assessment (such as journal writing, study groups, and portfolios) and collaborative reflection strategies (such as peer coaching and mentoring, and peer consulting). (NRC, 1996, p. 69)

Darling-Hammond Wei, Andree, Richardson, and Orphanos (2009) also stated the following: “Beyond the structure of the work day that accommodates daily professional collaboration, many high-achieving nations dedicate significant resources to professional development, often drawing on expertise beyond the school” (p. 17).

Quint (2011) mentioned that the ‘one shot’ workshop approach should not be the only source for teacher professional development programmes; she stated that other sources supporting continuous development should be utilized, such as intensive summer institutes and follow-up group sessions. The lack of such important activities for Saudi science teachers can be attributed to the educational policy which does not differentiate between highly efficient teachers and those of a lesser ability, and therefore teachers have a low level of responsibility for their professional development and wait for what is officially provided.

PD programme providers asserted that they directly receive the programmes from the Ministry of Eduation then, finally, they deliver them to the teachers (Sabah et al., 2014). This ‘top-down’ approach does not encourage teachers to be involved in the processes of designing their professional development programmes. The National Science Education Standards (NRC, 1996) stated that science teachers should be able to set their goals and take responsibility for their own professional development. Consequently, taking control can lead to ownership and self-empowerment for the teacher and ultimately bring about lifelong professional development.

5. Evaluation for Professional Development Programmes

Guskey (2002) introduced his model in evaluating PD programs; this model consist of five levels which are participants’ reaction, participants’ learning, organization support and change, participants’ use of new knowledge and skills, and students’ learning outcomes. This model is considered as comprehensive and coherent (Bolam & McMahon, 2004) Hoverer, PD programmes for science teachers in Saudi Arabia, seems not having a systematic, comprehensive, and coherent evaluation model. Sabah, Fayez, Alshamrani, and Mansour (2014) interviewed the providers of these programs and came up with that the providers reflect simple and general processes for evaluating PD programmes. The providers vary on their response when they asked about programme evaluation; they mentioned different approaches, and all of them indicated approaches related to three levels or less of Gyskey model. They emphasized some levels of Guskey model such as evaluating participants' reactions and participants' use of new knowledge. However, few of them mentioned participant learning, and none of them mentioned evaluating organization support and change. This result implies that there is a lack of comprehensive and systematic approach of evaluating science teacher PD programs. It seems that the providers used some different approach depends on their views of how can these programs be evaluated. In another study (Almazroa, Alorainin, & Alshaye, 2015) to probe teachers' opinions about the role of evaluation in PD. Teachers believe that PD activities lack follow-up and evaluation activities, which means PD programs and activities need to be rigorously evaluated to provide data for improvement

LESSONS LEARNED FOR SCIENCE TEACHER PROFESSIONAL DEVELOPMENT IN THE SAUDI EDUCATIONAL SYSTEM

We suggest here that a critical analysis of the current status of Saudi professional development in light of ideal professional development provides a sound platform for further development and implementation. The recommendations presented below are derived from the above discussion.

First Recommendation: Forming a Community of Practice

We recommend forming and supporting a community of practice among science teachers and building their leadership capacity. Teachers could communicate with other teachers about their experiences and even discuss with teachers from other schools. This could be done through forming a cooperative learning group at the school level, at the supervision office level, or at the educational district level. The promotion of collegiality and collaborative learning results in improvement on an individual level, as well as in the policies and practices of the community. The National Science Education Standards (NRC, 1996) recommend that the following changes should be emphasized: 1) from individual learning to collegial and cooperative learning, 2) from the teacher as an individual based in a classroom to the teacher as a member of a collegial professional community, and 3) from the teacher as follower to the teacher as leader. A learning community is a feature requested by the National Staff Development Council (NSCD) professional development standards (NSCD, 2001), and the National Council for Accreditation of Teacher Education (NCATE) professional development standards (NCATE, 2001). In fact, educational reform necessitates the formation of learning communities because cooperative activities play a major role in successful teaching (Butler et al., 2004).

Encouraging continuous professional communication among teachers could be obtained through building leadership capacity, so that a teacher becomes a member of a collegial professional community, and preparing teachers to be skilful school leaders who guide continuous instructional improvement. In their study on Saudi science teachers' views and experiences about continuing professional development, Qablan, Mansour, Alshamrani, Sabbah and Aldahmash (in press) recommend assigning science teacher leaders in each school who should be in direct contact with other teachers, to assist them in learning and applying new knowledge and skills and thus improve the academic performance of the students. Another option is to establish societies and associations which could lead to informal dialogue and formal meetings, thus creating a sense of community among science teachers as well as catering for their practical and emotional needs.

Second Recommendation: Learning v. Training

Training is the most common form of professional development and the one with which educators have the most experience. Although it is understandable to use a one-shot session and select a particular topic in which training and an initial level of understanding is necessary, 'one size fits all' should not be the dominant method of professional development.

Training is only one of the many ways to provide professional development. The National Science Education Standards recommend a change in emphasis from courses and workshops to a variety of professional development activities (NRC, 1996). Professional development for teachers should include active methods of teacher learning which mirror the methods to be used with students; teachers are adult learners and need different methods to suit their individual differences (AFT,2008). Professional development should be understood as learning activities and not as training activities, according to Mansour et al. (2012). A variety of forms and follow-ups with teachers could be utilized, such as discussions with colleagues, study groups, teacher networks, coaching, mentoring, and professional networks (NSDC, 2001). In addition, in their book entitled *Designing Professional Development for Teachers in Science and Mathematics,* Loucks-Horsley et al. (1998) list strategies for designing learning activities that best suit the specific goals and context as methods for professional development. These diverse strategies could be used as extended support for teachers to offer them a chance to ask questions and interact with professional developers and other colleagues and receive feedback (Garet, Porter, Desimone, Birman & Yoon, 2001).

Third Recommendation: Reflection Enhancement through Coherent Long-Term Plans

Changes in teachers' beliefs and practices do not happen in one event; it takes time and several experiences to reach attained goals (Adey, Hewitt, Hewitt & Landau, 2004; Darling-Hammond & Youngs, 2002; Garet et al., 2001; Joyce & Showers, 1988). Most professional development comes in the form of workshops focusing on discrete topics, where connection to the classroom is left to teachers' efforts. Such discrete workshops do not allow teachers the time to try out ideas in the classroom and reflect on the results.

Reflection helps teachers to personalize activities and enact new materials in the classroom. Educators point to the value of reflecting on teacher learning, as experience alone is not guaranteed to promote learning (Loughran, 2002). The effectiveness of professional development programmes increase when there is a continuous, coherent plan that provides teachers with opportunities for discussions and reflections. Meta-analysis studies have found a positive impact of time and the number of professional development programmes for science and mathematics on student learning (Blank & Alas, 2009).In fact, Science Education Standards (NRC, 1996) and NSDC Professional Development Standards (NSDC, 2001) include long-term, coherent professional development. We need to make sure that professional learning is organized so that it can be sustained throughout the school year. We recommend that reflection is to be a goal of professional development, and a structure should be provided to promote reflection tohelp teachers become reflective practitioners. Allowing time and instructions for teachers to reflect assists teachers by helping them feel comfortable enacting the reform-based curriculum in their classrooms.

Fourth Recommendation: Understanding Content through Inquiry

Supporting teachers in increasing their own content knowledge is an important feature of professional development, because teachers can be at a great disadvantage if they do not follow advancements and changes in science. One important call within the science teaching community is for professional development to focus on content (Garet et al., 2001). Furthermore, deepening teachers' content knowledge is one of the professional development principles, according to the American Federation of Teachers (AFT, 2008). Also, it is one of the professional development standards for staff development (NSDC, 2001).

Content knowledge is important because teachers cannot teach what they do not know; those who do not know the content well cannot teach it well. If teachers do not develop adequate content knowledge, they are likely to be uncomfortable with the material and consequently they may experience difficulties when teaching.

Teachers should learn content through inquiry, because part of knowing how to teach science is knowing what it means to do science (Garet et al., 2001). Varied approaches could be utilized, for example, teachers completing inquiry activities during workshops, forming groups within each school to investigate socio-scientific issues, and establishing partnerships with hospitals and other sectors to encourage teachers to participate in issues and problems related to science, technology and society. The National Research Council published a set of professional development standards in 1996, which include recommendations for science teachers to learn science content through inquiry (NRC, 1996). The professional development standards encompass the change in emphasis from learning science through lectures and reading to learning science through investigation and inquiry.

Fifth Recommendation: Organizational Support for Teachers

Providing support for science teachers is critical in order to implement what they are learning. Professional development needs strong, highly visible organizational support and could be implemented in many ways. Sufficient time, resources, and professional assistance should be provided to support teachers integrating new knowledge and skills into everyday practices.

Organizational support can be a key to the success of any professional development effort; for example, when teachers participate in a professional development programme on educational technology, and gain a thorough understanding and organize a variety of classroom activities based on computer simulation activities. Following their training, they try to implement these activities in schools where there is a lack of computers and the supervisor's focus is on students finishing the assigned book chapter. Another example is when teachers participate in a professional development programme on formative assessment, where teachers have to implement their training in schools where students are only graded on a summative assessment. Organizational policies and practices such as these can hinder the most valiant efforts, even when the individual aspects of professional development are done correctly. The lack of positive results is not due to inadequate professional learning; rather, it is due to organizational support that is incompatible with implementation efforts.

Sparks and Hirsh (1997) point to the importance of addressing individual learning and organizational change simultaneously to support one another, because gains made in one area could be affected by barriers in the other. Guskey (2000), in his professional development evaluation model, turns his attention to the organizational characteristics and attributes necessary for success in evaluating professional development programmes and activities. He believes that policies and organizational factors at the school, district, and national levels affect professional development content, processes, and outcomes.

CONCLUSION

In this chapter we have drawn on literature and our own experience as researchers and practitioners to show how teacher development can be designed effectively. The analysis of Saudi professional development that we have offered in this chapter shows the complexity of the task for those who have a role to play in making provision for science teacher professional development.

This chapter is concerned with improving professional development for science teachers in Saudi Arabia by providing a base of knowledge about the characteristics of effective teacher professional development programmes in science, so that programme designs are based on evidence of what successfully improves teachers' knowledge and skills, which will in turn advance the quality of teaching in science.

Moreover, this chapter identifies what research says works and what should happen to develop the best learning opportunities for science teachers. Not least, this chapter is a major first step toward developing a comprehensive set of policies and practices that will help better organize professional development for science teachers in Saudi Arabia.

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2. SCIENCE EDUCATION RESEARCH IN THE SULTANATE OF OMAN

The Representation and Diversification of Socio-Cultural Factors and Contexts

ABSTRACT

This chapter sheds light on science education research in Oman. More specifically, it analyses the representation and diversification of socio-cultural factors by science education researchers in Oman. To achieve this goal, a survey study was conducted with 16 science education researchers. They all held PhD degrees and conducted science education research. The findings indicate that the science education research in Oman does not factor in very many socio-cultural factors into its models. The impact of different factors (such as religious beliefs, non-Arabic spoken languages, age levels, school locations, mixed gender school settings) on science teaching and learning practices has not been given appropriate attention by science education researchers. The interactions among these factors within different Omani geographical regions, which differ in terms of cultural traditions and environmental diversity, seem to have been omitted. The reasons behind these findings are discussed. Also, the authors suggest some recommendations to enhance the representation and diversification of socio-cultural factors within science education research in Oman, and in the Gulf Cooperation Council (GCC) states.

INTRODUCTION

Educational research is the link between theory and practice. It informs the field of new theoretical trends, examines the applicability of these trends in particular local contexts, reports the interactions between certain cultural variables and different teaching methodologies, and disseminates good practice among practitioners in a certain field. On the other hand, research feeds the theory with required verification data and observations, helps to rectify the theory, builds up new theories and resolves theoretical conflicts. This theory-practice interactive linkage function of research motivates stakeholders in developed and developing countries to assign a considerable annual budget to research. Research is driven by the community and its concerns and thus it should not be value-free. It should bind to the socio-cultural issues and investigate the socio-cultural variables such as religion, language, economic

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status, lifestyle, gender, ethnicity, inequality, politics, values, habits, memories and history. Understanding how learning takes place and how meaning is made should be considered within the socio-cultural circumstances (Wickman & Östman, 2002). Our understanding of students' and teachers' beliefs, knowledge, skills and values becomes more mature when studied within the socio-cultural context. For instance, some students prefer the ideas they get from their surroundings, such as their religious beliefs, over the scientific ideas they study in their textbooks (Taber, Billingsley, Riga & Newdick, 2011). Other students justify that they are motivated to learn science to strengthen their religious beliefs. Also, students' beliefs about science differ based on their gender (Greenfield, 1996).

These findings show that students' learning is a result of the interaction between the individuals and the world around them (Cowie, 2005; Traianou, 2006; Wickman & Östman, 2002) and, thus, it is considerably influenced by the ideas they gain outside the school. As a result, socio-cultural influences lead some students to have multiple framework stances. Students choose a particular stance according to a particular context (Taber et al., 2011). In addition, research shows that there is a significant positive relationship between students' attitudes towards science and their socio-cultural background (Kesamang & Taiwo, 2002).

The diversity of students and teachers in terms of the socio-cultural variables has attracted the attention of science educators. In this regard, science education research has focused on 1) the linguistically and culturally diverse students, and 2) on multicultural approaches to science (Carter, 2008). In this chapter we are more concerned about the former, which insists on the right of every student to have access to scientific knowledge in order to be capable of functioning proficiently in the society. This entails developing the curriculum and designing the learning environment in a way that ensures this right (Carter, 2008; Lee, 2001). However, the attempt to investigate socio-cultural variables as a means to answer the question of' why we act as we do' is a complex task. Lemke (2001, 297) explains that:

> A sociocultural perspective on science education is sceptical and critical. Its most basic belief is that we do not know why we act as we do; we only know a few local reasons on a certain timescale and within a limited range of contexts. We do not know all the other reasons that arise from the functioning of our actions in far larger and more distant contexts and on longer timescales. As a research perspective this view seeks to elucidate the problems that arise from our limited view of the larger systems we inhabit, and to identify just how our actions do also function on many larger scales.

Research is a contextualized enterprise and involves its users in its development (Sursock, 2010). However, in the Arab world, of which the Gulf Cooperation Council (GCC) is a part, research in the social sciences is not valued as a significant trigger for social and economic development (Mazawi, 2010). In the GCC, the emergence of a research culture committed to the welfare of countries and their people is a new enterprise. In recent years the GCC governments have spent more money on research than ever before. There is an understanding by the GCC governments of the importance of research in the development of their countries. However, when compared to developed countries, the GCC is still lagging behind in this regard. For instance, while the average number of researchers per million inhabitants in the GCC is 251.7 (UNESCO, 2010), it is 2,639 in Europe, 4,181 in the UK, 4,663 in the USA and 5,573 in Japan (UNESCO, 2011). In addition, the average percentage of GDP spent on research remains less than 0.5 percent for most GCC states except for Qatar, which plans to spend 2.8%, and Saudi Arabia which is estimated to spend 0.5%. This percentage is around 2.0% in developed countries (UNESCO, 2010; Wilson, 2010).

Mazawi (2010) believes that research published by Arab researchers, including researchers from the GCC overly relies on structural-functional quantitative research methodologies, which oversimplify the complexity of social phenomena into statistical quantities. There is a lack of qualitative research methodologies, such as critical ethnographic and phenomenographic studies. This deficiency is empowered by the tendency of Arabic and GCC social science periodicals to publish quantitative research. This positivistic approach does not enable the voices of culturally diverse groups to be clearly heard. Mazawi believes that many Arab researchers still do not choose to use the qualitative participatory approach, for different reasons such as a lack of experience and an inability to apply the qualitative paradigm. Why should a country, for instance, a developing country, spend a considerable amount of money on research when it can adopt the research findings done in more developed countries by well-established research institutions? One of the reasons is that no two cultures are identical. Each culture has its own needs, problems and socio-cultural variables that play a significant role in shaping its identity, and therefore what works in one country does not necessarily work in another. The interplay between socio-cultural variables, such as religion, language, economic status, lifestyle, gender, ethnicity, inequality, politics, values, habits, memories and history, determines what is meaningful and fruitful in one culture, and what is not in another culture. Internationally, there has been considerable attention in science education to the influence of multiculturalism and cultural and linguistic diversity on the learning of science (Atwater, 1996; Bryan & Atwater, 2002; Carter, 2008). If we believe that knowledge constructions, such as science conceptions, are socially and culturally influenced, developed and transmitted, then science education researchers should help science teachers understand how different groups of learners are influenced by these processes. Science education research should provide science teachers with proper diagnostic assessment tools in order to uncover what diverse conceptual, cultural and linguistic frameworks students bring with them to the science classroom. In addition, taking these socio-cultural factors into consideration (for instance, when planning and conducting science education research) helps to ensure that the field of science education has the proper mechanisms to provide "equitable opportunities for all students to learn quality science" (Atwater, 1996, p. 822). This chapter examines the diversification and representation of some of these socio-cultural variables in science education research in Oman. However, the Omani context and the nature of science education research in Oman will be discussed first.

RESEARCH IN OMAN

Research in Oman is a relatively new enterprise. The research culture has been growing at a relatively slow pace (UNESCO, 2010). Oman is lagging behind in this regard. For instance, the number of researchers in Oman is low. In 2006, there were 230 researchers per million inhabitants. This number was lower than in some other GCC countries: Qatar (350), Bahrain (250) and Kuwait (260) (UNESCO, 2010). The Global Competitiveness Report (World Economic Forum, 2012) ranked Oman 86th in the local availability of specialized research and training services, 74th in the quality of scientific research institutions, and 54th in university-industry collaboration in research and development. Table 1 compares the GCC countries in these aspects. Oman lags behind Qatar, UAE and Saudi Arabia (KSA).

Table 1. World Economic Forum's ranking of the GCC states according to research institutions and services

Bahrain		*Kuwait*		*Oman*		*Qatar*		*KSA*		*UAE*	
rank	value	rank	value	rank	value	rank	value	rank	value	rank	value
Local availability of specialized research and training services [1 = not available; 7 = widely available]											
41	4.6	97	3.7	86	3.9	25	5.0	35	4.7	21	5.2
Quality of scientific research institutions [1 = very poor; 7 = the best in their field internationally]											
107	3.1	103	3.2	74	3.5	5	5.8	37	4.5	35	4.6
University-industry collaboration in research and development [1 = do not collaborate at all; 7 = collaborate extensively]											
115	3.0	120	3.0	54	3.8	9	5.4	31	4.5	26	4.6

Source: World Economic Forum (2012)

In Oman, the importance of research is stressed in its educational system at different levels (MoE, 2003). The Ministry of Education introduced a research principles subject in grade 11 and a graduation project in grade 12. The Oman Academic Accreditation Authority (OAAA) specifies research as one of its accrediting standards for all higher education institutions (OAAA, 2010). In 2008, the Higher Education Council decided that all public and private higher education institutions should adopt a general foundation programme which was designed for new intakes. This programme focuses on English, mathematics, information technology and study skills. One category within the study skills standards is research skills (OAAA, n.d.).

Three major sources of financial support have contributed greatly to the development of research in Oman. The first one comes from Sultan Qaboos University (SQU), the only public university which encompasses nine research centres: The Remote Sensing and Geographic Information Systems Center; The Omani Studies Center; The Center for Environmental Studies and Research; The Earthquake Monitoring Center; The Communication and Information Research Center; The Oil and Gas Research Center; The Water Research Center; The Center of Excellence in Marine Biotechnology (CEMB), and The Humanities Research Center (HRC). In addition, a new SQU research centre is under construction: the National Center for Hereditary Blood Diseases and Bone Marrow Transplant. SQU also encompasses three research chairs: The UNESCO Chair in Marine Biotechnology; The Shell Chair in Carbonate Geosciences; and The Research Council Chair in Nanotechnology for Water Desalination (SQU, 2009). In 1999, SQU established an internal grant system as an annual budget to support research projects done by its faculties and research centres. More than 859 research projects were sponsored during the period of 1999–2010, of which there were 43 educational research projects. In 2010, for instance, 74 research projects were funded to a total amount of R.O. 522,572 (USD 1,306,430). Only three of the projects were in education. The second major boost for research is the His Majesty's Trust Fund (HMTF) strategic research grant, which was established in 2001 to allocate an annual budget of approximately R.O. 500,000 (USD 1,250,000) to support the strategic research projects done by SQU. This grant has supported roughly 50 strategic research projects, of which four were in the education sector (SQU, 2010). The third major source of research funds comes from The Research Council (TRC), which was established in 2005. It supports researchers working in all public and private higher education institutions, and in different ministries. In 2009, TRC started the actual research funding and has funded about 42 research projects since then, with a total budget of R.O. 8 million (USD 20 million). Eleven research projects have been approved in the educational field, with a total budget of R.O. 509,179 (USD 1,272,947) (TRC, 2013).

SCIENCE EDUCATION RESEARCH IN OMAN

Only three science education projects have been funded by the previously mentioned sources. Two have been funded by the SQU internal research budget and one by the TRC. This small number is partially a result of the small number of science education researchers in the country. The total number of science education researchers who are PhD holders is about 13, of which there are 11 Omani nationals. There is one public Master's science education programme, which started in 2000, at SQU. The PhD programme was supposed to start in autumn 2013. There is also another Master's programme offered by Sohar University, which is a private institution. These two

Master's programmes have contributed greatly towards providing science education researchers and enriching the research experience of the faculty in both programmes. However, in most cases, more active science education researchers are PhD holders who work at higher education institutions.

Science education researchers have very limited interaction at the international level, and publish mostly in Arabic journals. This limits the visibility of their research (Ambusaidi & Al-Shuaili, 2009). However, there have been some improvements in this regard. Science education researchers in Oman have conducted collaborative research projects with their international counterparts, and published several publications with science education researchers in Australia, New Zealand, the UK, the USA, Lebanon, Egypt and Iraq. Unfortunately, the collaboration with their GCC counterparts is very limited. Some Omani science education researchers disseminate the results of their research at international conferences around the globe. Also, some of them have published in international education and science education journals. In addition, higher education institutions frequently host international conferences and symposiums, which allow science education researchers in Oman to interact with their international counterparts. The most recent ones were the 54th International Council on Education for Teaching (ICET) World Assembly (14–17 December, 2009), and the 7th International Science, Mathematics & Technology Education (SMTE) Conference (4–7 November, 2012) in collaboration with Curtin University, Australia.

To the knowledge of the authors, there has been no in-depth review of science education research in Oman so far. This chapter is an opportunity to review the research trends associated with science education research in the country. This review will help to understand what has been researched, and to guide future research projects, as well as the work of science education researchers. We hope that this review will be a foundation for a systematic review of the field and its research, in order to assist Omani science educators and higher education policymakers in designing reforms in science education. Also, this review will pinpoint the gaps in science education research, especially with regard to socio-cultural issues, and help to guide the field to direct some of its attention toward hitherto ignored issues and areas of research.

METHODOLOGY

Purpose and Research Questions

The lack of data regarding the overall understanding of the science research trends encourages a careful review directed towards science education researchers and their research projects. There are numerous unanswered questions regarding science education research in Oman. The current study is an attempt to answer some of these questions. Its purpose is to produce a detailed analysis of science education research done in Oman, and unravel its representation and diversification of socio-cultural factors and contexts. More specifically, the current study addresses the following research questions:

1. How is science education research diversified in terms of research topic, subject matter, type of participants, research design and methodology, dependent variables, type of data collection instruments, grade level, gender, school type, geographical region and statistical methods?
2. How are the results of science education research disseminated to the world?
3. What is the current and future impact of science education research on science education and science teaching practices, from the viewpoint of science education researchers in Oman?
4. How are socio-cultural factors (religion, gender, language, age, geographical region and environment) represented in science education research in Oman?

Participants

The participants are 16 researchers who have been carrying out research in science education in Oman. They are all PhD holders who either work in public or private universities or for the Ministry of Education. The speciality of nine of them is science education, and the specialities of seven are educational technology, educational psychology, statistics and measurements. These non-science education specialists were included in the study because of the research they have done related to science education. Fourteen participants are Omani and the rest are Arab expatriates. Only two of the participants are female.

Research Instrument

A survey was designed to produce detailed analysis of the research done by the participants. They were asked to answer 16 questions regarding the research they had done in science education. They talked about their research in general and not about each paper they published. The questions covered the following aspects:

- Number of publications (in science education)
- Research topic
- Subject matter
- Type of participants
- Research design and methodology
- Dependent variables
- Type of data collection instruments
- Grade level
- Gender
- School type
- Geographical region
- Statistical methods
- Language of publication
- Place of publication

- The impact of their research on science education and science teaching practices in Oman
- How they envision the future impact of their research on science education and science teaching practices in Oman

The instrument was reviewed by two science educators working at a public university in Oman, who checked the suitability of the instrument to answer the research questions, and the appropriateness of the phrasing of the questions. Then the instrument was piloted on the same two educators to ensure its readiness for distribution.

Data Collection and Analysis

The instrument was administered electronically on Google Docs. Participants received the link via an email and were asked to participate in the study. Two reminders were sent to each participant. The return rate was 100%. The data collection took two weeks. Then, the data were summarized using frequencies and percentages.

RESULTS AND DISCUSSIONS

This section summarizes the results of the study. The data are presented according to the research questions.

Research Question 1: How is science education research diversified in terms of research topic, subject matter, type of participants, research design and methodology, dependent variables, type of data collection instruments, grade level, gender, school type, geographical region and statistical methods?

Tables 2–15 illustrate data obtained from science education researchers in Oman.

Number of Publications

The average number of publications per researcher is 16.61. It ranges from one to 43 publications. It is noticeable that most of the publications are written by researchers working at SQU. This might be owing to the resources available and encouragement that researchers get at SQU.

Research Topic

Table 2 illustrates frequently investigated research topics by science education researchers in Oman. Teaching methods come first (75.0%), then thinking skills (68.8%). It is noticed that important topics have received less attention by science education researchers in Oman. Three of these topics are emphasized by National Science Education Standards (NRC, 1996); namely, nature of science, assessment and lab safety. Only five researchers (31.3%) have done research on the nature

Table 2. Frequently investigated research topics by science education researchers in Oman

Topic	*Number of researchers*	*%*
1. Teaching methods	12	75.0
2. Thinking skills	11	68.8
3. Learning difficulties	9	56.3
4. Learning theories	9	56.3
5. Science attitudes	8	50.0
6. Textbooks	8	50.0
7. Science teachers' beliefs	8	50.0
8. Science processes	8	50.0
9. Classroom practice	8	50.0
10. Classroom environment	7	43.8
11. Scientific literacy	6	37.5
12. Reading and readability	6	37.5
13. Science education standards	6	37.5
14. Students' beliefs	6	37.5
15. Science teacher's professional duties	6	37.5
16. Science, Technology, Society & Environment (STSE)	6	37.5
17. Motivation to learn	5	31.3
18. Nature of science	5	31.3
19. Mental models	5	31.3
20. Environmental education	5	31.3
21. Health education	5	31.3
22. Alternative conceptions	5	31.3
23. Modern technologies	4	25.0
24. Science laboratory	4	25.0
25. Assessment	4	25.0
26. Exemplary science teacher	4	25.0
27. Science ethics	3	18.8
28. Educational supervision	2	12.5
29. Sustainable development	2	12.5
30. Lab safety	2	12.5
31. Integration between science and other disciplines	2	12.5
32. Socio-cultural factors	1	6.3
33. History of science & scientists	1	6.3
34. Self-regulation	1	6.3

of science, four researchers (25.0%) have done research on assessment, and two (12.5%) have done research on lab safety.

Subject Matters

Table 3 illustrates frequently investigated subject areas by science education researchers in Oman. The results show that most of the researchers prefer doing their research in general science (81.3%). Among the three major subject areas, chemistry (68.8) comes first, and physics comes last (56.3%). Less attention is directed towards astronomy and earth sciences.

Table 3. Frequently investigated subject matters by science education researchers in Oman

Subject matter	*Number of researchers*	*%*
1. General science	13	81.3
2. Chemistry	11	68.8
3. Biology	10	62.5
4. Physics	9	56.3
5. Science & Technology	7	43.8
6. Astronomy	2	12.5
7. Earth sciences	1	6.3

Research Designs

Table 4 illustrates frequently used research designs by science education researchers in Oman. Data show that a very few number of science education researchers use qualitative research methods. There is a clear absence of qualitative research methodologies, such as ethnographic studies, grounded theory and critical studies. This reliance on quantitative research methodologies takes away the richness of data required to understand different science teaching and learning phenomena, and shrinks the complexity of these phenomena into numerical averages (Mazawi, 2010).

Table 4. Frequently used research designs by science education researchers in Oman

Research design	*Number of researchers*	*%*
1. Experimental/quasi-experimental	15	93.8
2. Analytical	12	75.0
3. Survey	10	62.5
4. Correlational	8	50.0
5. Case study	3	18.8
6. Phenomenographic study	3	18.8

Research Instruments

Table 5 illustrates frequently used research instruments by science education researchers in Oman. Questionnaires, achievement tests and psychological instruments are the most used research tools. The low percentages received by open and focus group interviews reflect the low tendency of science education researchers in Oman to conduct qualitative research. This result supports the claim made by Mazawi (2010) that Arab researchers tend to ignore qualitative research designs and rely heavily on questionnaire-based research.

Table 5. Frequently used research instruments by science education researchers in Oman

Instruments type	*Number of researchers*	*%*
1. Questionnaires	15	93.8
2. Achievement tests	14	87.5
3. Psychological instruments	14	87.5
4. Thinking skills instruments	11	68.8
5. Visual-Based instruments	9	56.3
6. Classroom observations	7	43.8
7. Diagnostic tests	6	37.5
8. Structured interviews	6	37.5
9. Open interviews	5	31.3
10. Focus group	2	12.5

Dependent Variables

Table 6 illustrates frequently studied dependent variables by science education researchers in Oman. Science achievement is the most studied dependent variable (93.8%).

Students' School Level

Table 7 illustrates the school level of students that participate frequently in research done by science education researchers in Oman. Students in Cycle II (grades 5–10) and grades 11 and 12 participate most of the time in science education research in Oman. Students in Cycle I (grades 1–4) receive less attention from science education researchers. This might be in part due to the nature of the teacher preparation programme in the only public university (Sultan Qaboos University), which is geared towards secondary education. Elementary education programmes used to be part of Teacher Preparation Colleges run by the Ministry of Higher Education. The Ministry has converted these colleges to Applied Science Colleges, in response to the demands of the labour market in the country.

Table 6. Frequently studied dependent variables by science education researchers in Oman

Dependent variable	*Number of researchers*	*%*
1. Science achievement	15	93.8
2. Thinking skills	12	75.0
3. Science attitudes	10	62.5
4. Classroom environment	10	62.5
5. Science processes	10	62.5
6. Problem-solving skills	9	56.3
7. Self concept	6	37.5
8. Self-regulated learning	5	31.3
9. Attitudes towards the method used	4	25.0
10. Motivation	4	25.0
11. Scientific literacy level	4	25.0
12. Decision-making	1	6.3

Table 7. The school level of students frequently participate in research done by science education researchers in Oman

School level	*Number of researchers*	*%*
1. Cycle II (grades 5–10)	15	93.8
2. Post Basic Education (grades 11–12)	14	87.5
3. College level	11	68.8
4. Cycle I (grades 1–4)	6	37.5

Student Gender

Table 8 illustrates number of research studies using male or female students by science education researchers in Oman. The data reflect almost equal opportunities for both genders to participate in science education research in Oman.

Table 8. Number of research studies done on male or female students by science education researchers in Oman

Number of studies conducted with male students only	*Number of studies conducted with female students only*
62	59

Teachers' School Level

Table 9 illustrates the school level taught by science teachers participating frequently in research done by science education researchers in Oman. Cycle I (grades 1–4) and college teachers are the least likely to participate in science education research in Oman. Also, science teachers in grades 11 and 12 (81.3%) receive less attention than their students (87.5%, from Table 7). The low percentage received by college level teachers (31.3%), who teach science courses at university level, might reflect a research gap when compared to the percentage received by college students (68.8%, from Table 7). To understand the problems faced by college students with respect to the teaching and learning of science, their instructors should be involved more frequently in science education research.

Table 9. The school level of science teachers participating frequently in research done by science education researchers in Oman

The school level of science teachers	*Number of researchers*	*%*
1. Cycle II (grades 5–10)	15	93.8
2. Post Basic Education (grades 11–12)	13	81.3
3. Cycle I (grades 1–4)	6	37.5
4. College level	5	31.3

Geographical Region

Table 10 illustrates frequently chosen regions by science education researchers in Oman, from which to draw their samples. Muscat (93.8%) comes first, then Batina South (81.3%) and Dhakhelya (81.3%). Muscat is where most of the science education researchers reside and work. The other two are the neighbouring regions to Muscat. There is very little attention is given to three other regions; namely, Wosta (31.3%), Dhufar (25.0%) and Masandam (25.0%).

School Location

Table 11 illustrates frequently chosen school locations by science education researchers in Oman. Schools located in the cities received the most attention (93.8%), while those in the mountains received the least (43.8%). This result shows that schools located in rural areas might not receive enough attention from science education researchers, so the voices of diverse groups in these schools might not heard.

Table 10. Frequently chosen geographical regions by science education researchers in Oman

Region	*Number of researchers*	*%*
1. Muscat	15	93.8
2. Batina South	13	81.3
3. Dhakhelya	13	81.3
4. Batina North	9	56.3
5. Sharquia North	9	56.3
6. Sharquia South	8	50.00
7. Dhahra	8	50.00
8. Buraymi	6	37.5
9. Wosta	5	31.3
10. Masandem	4	25.0
11. Dhufar	4	25.0

Table 11. Frequently chosen school location by science education researchers in Oman

School location	*Number of researchers*	*%*
1. City	15	93.8
2. Village	12	75.0
3. Mountain	7	43.8

Statistical Methods

Table 12 illustrates frequently used statistical methods by science education researchers in Oman. The most used methods are frequencies and percentages (100%), t-test (100%), ANOVA (93.8%) and correlation (87.5%). Factor analysis (18.8%), regression analysis (18.8%) and MANCOVA (12.5%) are the least used statistical methods. The same trend is observed in Turkish science education research (Sozbilir, Kutu & Yasar, 2012).

Research Question 2: How are the results of science education research disseminated to the world?

Table 13 illustrates the languages most frequently used for publication by science education researchers in Oman. Most of them (68.8%) use the Arabic and English languages to disseminate the results of their research. Only five (31.3%) do not

Table 12. Frequently used statistical methods by science education researchers in Oman

Statistics	*Number of researchers*	*%*
1. Frequencies & percentages	16	100.00
2. t-test	16	100.00
3. ANOVA	15	93.8
4. Correlation	14	87.5
5. MANOVA	9	56.3
6. Chai square	8	50.00
7. ANCOVA	7	43.8
8. Factorial analysis	3	18.8
9. Regression analysis	3	18.8
10. MANCOVA	2	12.5

publish in English, and there are no researchers who publish only in English. As for the type of dissemination, Table 14 illustrates frequently used types of dissemination by science education researchers in Oman. Conference proceedings (87.5%), GCC Arabic periodicals (75.0%) and other Arabic periodicals (75.0%) attract most of the researchers. Half of the science education researchers (50.00%) have published in the only Omani educational periodical, which is hosted by Sultan Qaboos University: namely, the *Journal of Educational and Psychological Studies.* Publishing in English periodicals attracts more than half of the researchers (62.5%). This leaves much of the research done in science education in Oman unheard of by the international community. This is a disadvantage that supports the claim of Ambusaidi and Al-Shuaili (2009), that the tendency of science education researchers in Oman to publish most of their work in Arabic limits the visibility of their research.

Table 13. Languages most frequently used for publication by science education researchers in Oman

Publication language	*Number of researchers*	*%*
1. Researchers publish in both Arabic & English	11	68.8
2. Researchers publish in Arabic only	5	31.3
3. Researchers publish in English only	0	00.00

Table 14. Frequently used types of dissemination by science education researchers in Oman

Periodical	*Number of researchers*	*%*
1. Conference proceedings	14	87.5
2. GCC Arabic periodicals	12	75.0
3. Other Arabic periodicals	12	75.0
4. English periodicals	10	62.5
5. An Omani periodical	8	50.00

Research Question 3: What is the current and future impact of science education research on science education and science teaching practices, from the viewpoint of science education researchers in Oman?

Table 15 summarizes the viewpoints of the science education researchers, regarding the current and future impact of their research on science education and science teaching practices in Oman. Some researchers (43.8%) value the impact of their research in terms of providing their fellow researchers and postgraduate students with new valid and reliable data collection instruments that suit the local context. They also believe that the results of their research serve as a starting point for subsequent research done by other science education researchers in the Sultanate. A group of science education researchers in Oman (43.8%) highlight that their research has helped to improve in-service and pre-service teacher training practices in the field. Six science education researchers (37.5%) feel that the research they have conducted has helped in constructing a clearer and more comprehensive picture of the variables that play a vital role in shaping science education practices in Oman. Also, four researchers (25.0%) believe that the instructional methods they have explored in their research have been used as topics for training pre-service and in-service science teachers. They underline that they have introduced new teaching methodologies that have not previously been known or practised by science teachers. Four researchers (25.0%) also believe that they have enriched the Arabic and English science education literature with an understanding of the Omani context. Other points mentioned by one or two researchers include developing the research culture in the country, and improving science textbooks. Interestingly, two researchers comment that they do not think that their research has improved the practice of science education. They feel that the field does not encourage such positive impacts, and that it needs a lot of work in many respects. Due to low percentages, some of these results can not be generalized. There is a need for further research using more thorough research methods such interviews and focus groups to explore the issues related to the impact of science education research in Oman.

Table 15. The impact of the research done by science education researchers on science education and science teaching practices in Oman

Type of impact	*Number of researchers*	*%*
1. Design new assessment and data collection tools and serve as a foundation for new research studies by researchers and postgraduate students.	7	43.8
2. Improve the pre- and in-service training.	7	43.8
3. Improve science teaching practices and understand their interconnecting variables within the Omani context.	6	37.5
4. Introduce new teaching strategies in the field.	4	25.0
5. Enrich the educational literature, written in both Arabic and English, with an understanding of the Omani science education context.	4	25.0

Table 16 summarizes the viewpoints of the science education researchers regarding the current and future impact of their research on science education and science teaching practices in Oman. Half of the researchers (50.0%) believe that the field should take their research recommendations into consideration. Seven of them (43.8%) focus on directing their research at improving students' thinking skills and attitudes towards science, as cornerstones for elevating their achievement and performance. Five researchers (31.3%) believe that science education research should be tailored towards improving pre- and in-service training, as a key strategy to improving science teaching practices in the country. Three researchers (18.8%) consider enhancing science literacy as an ultimate product for their research. Also, three researchers (18.8%) call for more funds for science education research, and ask for the involvement of more teachers in conducting these research projects. Some other points are suggested by one or two researchers, and cover assessment, science curriculum, mental models and technology-based school science laboratories. Interestingly, two researchers recommend that science education research should be expanded to include parents, students with learning difficulties, and other stakeholders. Again, due to low percentages, there is a limitation regarding the generalizability of these results.

Table 16. The future impact of the research done by science education researchers on science education and science teaching practices in Oman

Type of future impact	*Number of researchers*	*%*
1. The field should study the results and the recommendations of the studies and implement some of them.	8	50.0
2. Improve the teaching inside the classrooms, in order to improve students' thinking skills and their attitudes towards science.	7	43.8
3. Improve the professional development of in-service and pre-service science teachers.	5	31.3
4. Enhance scientific literacy.	3	18.8
5. Increase the funded research projects in science education and involve more teachers in these projects.	3	18.8

Research Question 4: How are sociocultural factors (religion, gender, language, age, region and environment) represented in science education research in Oman?

This section is organized by sociocultural factors (religion, gender, language, age, region and environment). Related data presented under the previous research questions are used to answer this research question.

Religion

Islam is the dominant religion in Oman, where 98% are Muslims and the remaining 2% are Christians, Buddhists and Hindus. Besides being a religion of theological and ethical beliefs, Islam is also a way of life. It systematizes the social, political and economic relationships between people in society (Mansour, 2009). In Oman, as in some other Muslim countries, three aspects of the Islamic religion have greatly influenced the practice of science education. These are cultural understandings of how Islam influences science learning and teaching. The first one is that Islamic beliefs work as a strong driver for many Muslims to explore the nature around them. Many Muslims are eager to learn about the secrets of their bodies, the creatures around them and the whole universe. This is encouraged by some verses of the Koran, which urge Muslims to think of the secrets of creation. Many Muslims consider these secrets as signs that signify the glory of the Almighty Creator. Some Muslims even seek rewards from God by doing so; therefore, science learning, for some, becomes a kind of worship. The second aspect is a concept called the scientific miracle of the Koran. Some Muslim scientists have devoted their scientific practices to studying the verses of the Koran from a scientific point of view. Thus, it is common to see science teachers use verses from the Holy book to get the students' attention when they discuss some scientific concepts and explanations. The third aspect of the relationship between religion and science education is to do with evolutionary theory, which is not taught at any level in Oman, including the college level. Many Muslims believe that the theory of evolution contradicts their belief that God is the Creator. Although there are some Muslims who believe that there is no such contradiction, curriculum designers in Oman have decided not to include evolutionary theory in the science curriculum.

The literature shows that some religious beliefs might hinder science learning, and others might motivate students to learn science (Mansour, 2009; Taber, Billingsley, Riga & Newdick, 2011). Undoubtedly the interactions between religion and science in Oman influence the science learning of many Omani students. The question is, how is it influenced? Science education researchers have not attempted to answer this crucial question. According to Tables 1, 15 and 16, science education researchers have neither used religion as a topic of research, nor did they mention it in the future impact of their research on the practice of science education in Oman. Therefore, the voices of Omani students and teachers, whose beliefs and knowledge constructions are influenced by religion, remain unheard. It would be interesting if students at different grade levels are interviewed about the religious believes that could motivate them to learn science. Also, science teachers who frequently refer to verses of Koran while teaching science could be identified and then interviewed to understand what motivates their decision of integrating science and religion and whether they feel that this adds value to their teaching and students' understanding and appreciation of science.

Gender

Male and female students are equally represented in science education research in Oman. According to Table 8, both genders have been included almost equally as research subjects. Grades 5–12 in public schools in Oman are segregated according to gender. However, this is not the case for Cycle I (grades 1–4) in public schools, private schools or public schools located in areas with a small population, such as those located in the mountains and in rural areas. In addition, college level is mixed gender education in Oman. A question of the effect of co-educational education on science teaching and learning is not addressed by science education researchers in Oman.

Language

Although the Arabic language is the official language of Oman, there are other languages spoken widely by large Omani groups; for example, Swahili, English, Balochi, Hindi and Urdu. Mehri and Persian are also spoken in certain regions of

Oman. For instance, Mehri is spoken by almost 51,000 people in the southern part of Oman, close to Yemen. In addition, there are some other languages that are spoken by small Omani groups; for example, Jibbali, Kumzari, Bathari, Harsusi, Hobyot, Khojki and Zidgali. The estimated numbers of speakers of these languages ranges from 400–7,000 (Ghaudhuri, 2013). The children of some families whose mother tongue is not Arabic start to learn Arabic at school. This phenomenon has caused an educational problem for those children. They struggle in their first school years since all subject matters are taught in a language foreign to them. None of the science education researchers surveyed in this study has explored this phenomenon, or how it might affect the teaching and learning of science.

- To give the reader a sense of the size of the problem, the southern part of Oman (the Dhofar Governance), which hosts 9.3% of the total population of Oman (Ministry of Natioanl Economy, 2011), is illustrated here as an example. Most of the people there speak one or two languages beside Arabic. Unfortunately, this region receives most of the newly qualified teachers, including science teachers, who come from the northern parts of Oman where these languages are not spoken. Neither the Ministry of Education nor the pre-service training and preparation programmes prepare these teachers to deal with these students with respect to the cultural differences between the two parts of Oman; and
- The language difficulties that these students face.

Therefore, these new graduate teachers experience a reality shock that they face during their first years of teaching. These teachers might spend one or two years in Dhofar, then they go back to the northern regions closer to their home towns. They are replaced by new graduates. Therefore, some students in the south, where many of them start learning Arabic at school, always have one or two teachers who are newly qualified, culturally different, do not understand the languages that students speak, and are not equipped to deal with these culturally and linguistically diverse students. Science education researchers have not explored this problem, and have remained unattracted by it.

Age

Table 7 shows that a small number of researchers tend to do research on younger students. Table 9 supports these findings. Science teachers who teach Cycle I (grades 1–4) are under-represented, and include a small number of researchers in science education research. Cycle I schools are mixed gender and taught by female teachers only. This context produces a learning environment in which age and gender factors interact together, to shape the knowledge, skills and dispositions gained by grades 1–4 students. This learning environment is different from the one in grades 5–12, where students study in separate gender schools, and are taught by male or female teachers according to their gender. Science education researchers in Oman, by not giving younger students enough attention, miss the opportunity to understand the nature of epistemological and pedagogical processes related to science education that take place at the Cycle I stage. Not fully understanding how science learning takes place in grades 1–4 in Oman distorts the picture that science education researchers try to make for science learning in Cycle II (grades 5–10), and the grade levels above.

Geographical Region

Oman is a diversified country in which its geographical regions have some cultural attributes that are different from each other. However, Table 10 shows that three regions – namely, Dhofar, Massandam and Wosta – are under-represented in science education research: they are not given the same attention as the other regions. These three regions possess tremendous cultural diversity in terms of spoken languages other than Arabic, number of mixed gender schools, and school location (i.e. city, village and mountain). This interaction between cultural variables has not yet been explored by science education researchers.

Environment

Oman was hit by two strong hurricanes in 2007 and 2010. They resulted in major damage to infrastructure. Since then, the environment has become a focus of the government and the media. The Ministry of Education has introduced a new subject in grade 12, called Environmental Sciences. In science education, environmental issues attract a number of researchers. Table 2, as we saw earlier, shows that researchers have focused on topics related to the environment and society, such as Science, Technology, Society & Environment (STSE) (37.5%), environmental education (31.3%) and sustainable development (12.5%).

CONCLUSIONS AND RECOMMENDATIONS

Traditional science education research does not focus very much on the socio-cultural context and the diverse cultural nature of the learners (Atwater, 1996). The results of the current study indicate that science education research in Oman falls into this category. Since research is contextualized enterprise and should engage its users (e.g. students, teachers and parents) in its development (Sursock, 2010), science education research in Oman should involve all cultural groups, and consider the diversity of the Omani community in its strategic plan. Omani learners are culturally and linguistically diverse. The voices of learners with disabilities, learners who do not speak Arabic at home, learners with learning difficulties, learners of different ages, learners who live in the mountains, or reside in a culture that differs from mainstream Omani culture, should be heard. Teachers might spend their time making these students acceptable members in the dominant culture, while these students spend their time trying to define who they are. The two sides have different value systems and might not manage to communicate successfully and inter-culturally with each other (Atwater, 1996). Thus, these students should not be left to passive-resistance behaviour, such as silence, evasiveness and manipulation when studying science by a newly prepared science teacher, who is culturally different and not equipped with the proper understanding, skills and disposition to deal with them. Therefore, science education research should work constructively, to ensure that equal learning opportunities are given to all students to learn high quality science (Atwater, 1996). It should explore the possibility of accommodating all learners, and lay the ground for culturally responsive science teaching practices. There is a need to initiate a dialogue among science education researchers, their institutes, the Ministry of Higher Education, the Ministry of Education and The Research Council, on the need for multicultural education research in general and multicultural science education research in particular.

The previous illustration and discussion of the socio-cultural factors that might interact with the practices of science education in Oman reveal an overlap between different variables. For instance, the three Omani geographical regions (i.e. Dhofar, Wosta and Massandam) which receive less attention from science education researchers, have at least six spoken languages in total. Also, mixed gender and mountain schools are high in number. In addition, these regions possess natural environments that are different from the rest of Oman. For instance, while the northern parts of Oman are hot during the summer, Dhofar is rainy with moderate temperatures in the mid-twenties Celsius during the summer. Massandam is a mountainous region located on the Strait of Hurmuz, and Wosta is a completely desert region populated by Bedouins. This amalgamation of different variables (e.g. religious beliefs, region, language, gender, school location, culture and environment) requires significant attention by science education researchers, to study the effect of interactions between these variables for the learning of science. An example of the studies that might be done in this important area of research are qualitative studies that explore this phenomenon from different aspects and include all stakeholders, in order to estimate the size of the problem and its effects on students' learning of science. The results of these qualitative studies could be used to design inductive programmes for in-service science teachers, especially the new ones, to equip them with differentiated instruction for culturally and linguistically diverse students.

A reason for the under-representation of the socio-cultural factors in science education research in Oman might be the research methodology used. The dominance of quantitative research methodologies gives little chance of generating knowledge effectively, regarding the involvement of diverse groups and socio-cultural factors in science education, and leaves researchers with little space to examine what science education and its enterprises mean to diversified local contexts in Oman. Relying heavily on quantitative research does not construct the big picture of the societal influence on learning science and the interaction between students' scientific beliefs and their cultural surroundings. Individual and focus group interviews with science teachers and students and analysing their written reflection on the socio-cultural factors that could influence their epistemological beliefs are examples of research approaches that could produce in-depth knowledge to understand the interaction between different aspects of science education and socio-cultural factors. An important aspect that we believe contributes significantly to the limit number of qualitative research in science education in Oman is the backgrounds of the researchers themselves. None of the researchers who we involved in the current study had qualitative research as his/her main research agenda. Only two of them were known for conducting mixed research methods from time to time. Also, the preparation of young researchers in Oman in the main university (i.e. SQU) focuses heavily on quantitative research. No course is devoted to qualitative methodologies.

From the responses obtained from science education researchers to the third research question, regarding the current and future impact of science education research, it does not seem that science education research in Oman has an impact on policymaking with regard to the strategic planning for science education reform at the national level. The literature shows that this might be the case in other GCC and Arab countries (Mazawi, 2010). Some researchers who participated in the current study did not feel that the policymakers took the findings and recommendations of their research seriously. They cautioned that the science education field in their country required a great deal of work in order to improve.

Another important factor that greatly relates to the low impact of science education research on society and policymaking processes in Oman and the GCC is the nature of most GCC universities, which are teaching universities with a high teaching load that leaves academics with little time to conduct thorough research projects (Brint, 2010; Ma, 2010). Instead the researchers conduct quick quantitative survey-based research that contributes inadequately to educational reform (Mazawi, 2010). In addition, science education researchers in Oman are working in a few higher education institutions in small numbers, with no academic association that organizes their scattered research efforts. Such an association also does not exist at the GCC level. Also, the GCC states have very limited mobility of academics among higher education institutions and across different states (Mazawi, 2010). This makes the collaborative research in science education and networking between GCC researchers very limited.

Efforts should take place to make the findings of the science education research in the GCC reach the policymakers and impact the community. For instance, science education researchers should engage in country-wide research projects that would help reform the science education practices and policies. Such projects will attract more local schools, science teachers and science teaching experts who become to realize the importance of science education research and might play a role in convincing policymakers to take the research findings more seriously. In addition, generally speaking, GCC universities should facilitate the dissemination of their researchers' findings within the local professional communities. In this regards, conferences which engage different stakeholders should be funded by universities and become more frequent. Also, science education researchers should be encouraged to conduct research projects that have a high impact in the community instead of small-scale research projects. In this regard, different types of incentives might be provided to science education researchers.

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3. SCIENCE TEACHER PROFESSIONAL DEVELOPMENT NEEDS IN THE UNITED ARAB EMIRATES

ABSTRACT

Educators, policy makers, parents and others are concerned with student attainment, which is directly linked to the initial competencies of teachers and their ongoing professional development. This chapter sets out to critically present the key aspects of science teacher professional development in the UAE, such as teaching excellence, the advancement of learning, critical thinking and meticulous and thoughtful assessment of students. In particular, the chapter envisions a way forward to present the best science training model that develops teacher competencies and effectively prepares students for the 21st century. The chapter provides examples of effective science teacher professional development using blended research methods, employing an analytical literature review along with the use of questionnaires and interview techniques. Finally, it presents a Science Teacher Professional Development (STPD) model that is based on the educational and socio-cultural contexts of the UAE and that allows for teacher growth; and consequently, positively impacts student learning.

INTRODUCTION

Free, publicly provided education has been a central tenet of the social contract in every country in the Middle East and North Africa since independence. Post-independence governments have significantly expanded their education systems, driven by rapidly expanding youth populations, and the need to build nationhood and to establish political legitimacy and popular support for new regimes through making education a fundamental right of citizenship. It is well known that population growth in Arab countries is among the highest in the world, which makes providing basic education a major challenge (Akkari, 2004). However, education systems in the region, with a few exceptions, now provide basic education to most children.

One of the most pressing needs in the Gulf Cooperation Council (GCC) countries is to develop citizen competencies to lead the long awaited development of their nations. While oil development is seen as a key factor for financial and social

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 49–68.

development, a lasting effect of such development can only be achieved if citizens are adequately prepared in all different walks of life and especially in education and the sciences. The United Arab Emirates (UAE) is an active member of the GCC and may become a strong partner for the EU in a number of domains. In its recent country report debriefing, the European Union (EU, 2012) introduced the report by stating that the UAE has the most open and diversified economy in the region.

Purpose and Rationale of the Chapter

This chapter sets out to critically present the key aspects of science teacher professional development (STPD) in the UAE, such as teaching excellence, advancing learning, critical thinking, and meticulous and thoughtful assessment of students. In particular the chapter envisions a way forward to present the best science training model that develops teacher competencies, and effectively prepares students for the 21st century. Educators, policy makers, parents and others are concerned with student attainment which is directly linked to teacher initial competencies and their ongoing professional development. Indeed, sustained professional development for teachers is a central focus in improving the quality of teaching (Posnanski, 2010).

In particular, this chapter aims to present key aspects of the STPD in the UAE, and how effective and sustainable they are. Additionally, it suggests a model for the best STPD for the UAE context that advances traditional ways of providing teacher training and further incorporates new approaches that can be used in the UAE and the GCC region. The author's own experience in planning and providing many science professional development activities will be included. Data will also be drawn from a questionnaire developed specifically to elicit teachers' and administrators' perceptions regarding PD.

There appear to be some main questions worth pursuing in relation to STPD in the UAE which are listed here:

- What can be considered as effective examples of science teacher professional development (STPD)?
- What are some examples of recent professional development sessions that you've attended?
- Who initiates plans for professional development activities?
- What types of professional develop you need in your area of teaching?
- What aspects of professional development do science teachers feel assist them in their practice?
- What is your most preferred professional development delivery style?
- What are the challenges that are encountered in STPD?
- How can professional development for teachers be understood in the UAE context?
- To what extent do teachers have the opportunity to be professionally developed, with or without governmental support? and

- What, if any, are the best possible models of teacher professional development in the UAE?

Diaconu, Radigan, Suskavcevic and Nichol (2012), and Villegas-Reimers (2003) provide exemplary models of professional development, e.g., organizational partnership models and small or individual models, which will be used as a frame of reference to compare examples of science professional development in the UAE. In relation to the content of professional development based on these models, two dimensions are used: (1) personal, social and professional; and (2) a continuum from transitive to transformative. Additionally, this chapter envisions a third dimension, the instructional continuum from expository to independent (Forawi & Liang, 2011). Therefore, this chapter aims to describe examples of STPD using blended research methods, employing an analytical literature review along with the use of questionnaires and interview techniques. It also aims to provide a STPD model that is based on the UAE and GCC context.

EDUCATION IN THE UNITED ARAB EMIRATES

The UAE is currently undergoing a rapid expansion, with Emirati government fuelling growth by investing the proceeds of high oil prices and international investments into a huge array of public and public-private enterprises. Recognizing that this increase in available funds is not in itself a long-term growth strategy, the UAE government has made a number of public commitments to strengthening the country's macroeconomic foundations, including emphasis on education reform. The education status in the UAE is well stated in the World Economic Forum report as follows:

> Education and innovation: One of the UAE's key challenges is to ensure that its education system provides nationals with the skills demanded by its growing private sector, thereby helping to diversify the country's industries and redressing the demographic imbalance in its workforce. The scenarios demonstrate that ensuring highly-qualified Emirati workers with relevant skill sets are available in an innovative economy is crucial to the country, both in terms of capitalizing on present oil wealth and achieving its goals of long-term economic stability. (World Economic Forum, 2012, p. 8)

Science education must be considered as a main focus of educational reforms in the UAE. This can only be true if the UAE strategically plans to be successful as a nation in developing its citizens and advancing as a nation, then science education should have a major emphasis in the reform agenda. Science literacy, standard-based education, guided-inquiry instruction, effective assessment and other important new directions have been the focus all over the world for several years now (such as in the US, UK, Canada, Australia, and Singapore). These directions provide substantive frameworks for curriculum development and policy making to better educate children to be future citizens. In order to meet the challenge of instituting and implementing such new science frameworks, teachers are expected to keep up-to-date with the advancements in science and technology and to continue transforming themselves from technicians to professionals. They will move from merely delivering textbook knowledge to students, to intellectual professionals who are capable of facilitating student active learning and making decisions on curricular, instructional, and assessment issues to effectively impact their students. To help teachers grow professionally in this new context, there is a pressing need for developing and instituting a new model for professional development that can foster the growth of teachers from technicians to professionals (Fwu & Wang, 2012).

Teacher shortages have become a global concern. Similarly, there has been an acute shortage of Emirati male teachers in schools in general, but especially in the public sector, as the Knowledge and Human Development Authority (KHDA, 2011) revealed that although 90% of female teachers in Dubai's girls public schools are Emirati, only 4% of male teachers in the boys schools are Emirati. This is a major concern as Dubai is the second largest Emirate. There is such a heavy reliance on expatriate teachers which may create, on one hand, a major concern with regard to educational reform and 'emiratization' of jobs. On the other hand, this situation of the lack of Emirati male teachers, especially for boys' schools, raises the need for professional development of teachers to help familiarize them with the UAE educational system and further assist them to implement the new curricula. Science, mathematics, and English are regarded to be of paramount interest in the reform agenda of the UAE. While there has been a growing debate on striking a balance among school subjects, especially Islamic and Arabic studies, the emphasis is still on English, science, and mathematics. This is unique to the country and differs from global reform which still has major emphasis only on reading, writing and maths (e.g. No Child Left Behind, US). In particular, several ambitious initiatives were launched to improve students' science attainment. Yet, teachers are still the cornerstone for any improvement that may be foreseen for students.

Education is a profession that is based on systems, philosophies, and standards for instruction which are all reflected within teacher professionalism. Initial teacher qualifications can potentially have a significant effect on the quality and impact of the educational system. More importantly teachers should continuously be developed to be presented with up-to-date strategies and the new pedagogical content knowledge in order to positively impact students' learning experiences.

Education is considered as a key for the sustainable development of the UAE. The Ministry of Education has emphasised the goal of the strategic plan of 2014 to build a knowledge-based society. The UAE has one of the lowest student-to-teacher ratios in the world (15:1). Education is compulsory up to ninth grade, although, according to the U.S. Department of Education, this requirement is not enforced (New York Times, 2013). A small percentage of children pass school age without being admitted to school, or start school at a late age, while others attend after evening school, due to parental neglect or financial or other reasons.

UAE children are required to attend gender-segregated schools at all the three public school levels, elementary, middle, and secondary. However, students are segregated after grade 4 in the private sector. The education budget has increased steadily over the past 20 years. In 2012, 47% of the UAE's federal budget was channelled into social development (public education, higher education, health, social affairs, Islamic and cultural affairs, youth and community development) (EU, 2012). In order to improve education in the UAE, the government has implemented policies of free public schools, colleges and universities for UAE citizens. Therefore, the government is continuously attempting to improve public education, which is considered to be lagging behind private education, by building new schools, institutes, colleges and universities in all the seven emirates in the country. It is also investing in teacher preparation and qualification, teaching quality, staffing salary, and the upgrading of technology.

The private education system is also well developed and attended by 40% of the students from K-16 with diversified curricula that are modelled on different systems, e.g. the US, UK, Australia and India. The structure of the educational system in the UAE mainly follows a model of primary education that starts from the age of five which is obligatory from kindergarten to grade 6. The secondary education from 12–18 years is composed of two cycles of three years each (preparatory school from grade 7 to grade 9 and the secondary education programme from grade 10 to grade 12). Tertiary education is also well developed. There are also many foreign universities in the UAE, including representation from almost all the European, American, and Australian institutions, such as the Sorbonne and Harvard. However, science teaching is faced with challenging problems as reported by the local newspaper, the *National* (2012) which stated that the lack of English preparation and poor teaching are turning Emirati schoolchildren off science and technology. This section discusses current practices of science education in the UAE, the Madares Al Gad (MAG) initiative, teaching science in the English language, and science teacher availability and qualifications.

Science Teaching in the UAE

Tairab (2010) has indicated that increasing both science teachers' content knowledge of their discipline and their expertise in pedagogical content knowledge (PCK) has been both challenging and overwhelming to many teachers and educators in the UAE. In elementary education, for example, the lack of strong content knowledge in science is particularly evident. One of the new reform directions that aimed to strengthen science education and makes content relevant to multiple areas is the interdisciplinary Science, Technology, Engineering and Mathematics (STEM) approach. In the UAE, there is no official STEM education embedded in school curricula. However, the students' interest in science and its related subjects was sparked and made evident in their participation of school and college projects with interdisciplinary nature. A rare example is a10-day STEM program that was run in December, 2012 at Khalifa University, Abu-Dhabi, that hosted 181 national students from private and government schools who participated in the Advanced Technology Investment Company (ATIC's 2nd TECH QUEST, 2012). While this programme is not widely used, it is aimed to enhance participants' interdisciplinary research skills, introduce K-12 students to undergraduate research, and shape their career choices.

Although the UAE fell 10 places in the Innovation Global Index, compared to the previous years, to rank at 34 in 2012, experts indicated that it seemed to be a short-term setback. Investing heavily in science and education could help to elevate the UAE to the top ranks of such an index (Jones, 2012). Dubai, in particular, is seen as the centre of the country's economic development, with Abu Dhabi now rising as well. The country developed frameworks for all the school subjects including science for K-12 in an attempt to strategically plan to develop a systematic science education reform. However, this movement is facing many obstacles and has not been seen as influential. The frameworks of science seemed sufficient although with a lack of real contextual and cultural connections as they are mostly drawn from western documents with little or no relevance to the country's culture and heritage. Also, with a lack of follow-up and evaluation of the many educational initiatives, these reforms remain questionable and open to doubt.

History, grammar, literature and the Arabic language are taught in the native language (Arabic), whereas mathematics and sciences are generally taught in the English language. In the UAE, (i.e., Dubai & Abu Dhabi emirates), and in most Gulf countries, there is a dual language focus mainly in core subjects such as English, Math and Science. Recognizing a constant need for progress (Nagrath, 2014), the UAE has sought to implement and monitor high quality education standards by undertaking new policies, programmes and initiatives. Throughout the Middle East, educational advancement is often impeded by insufficient focus on the English language and inadequate provision of technology, as well as of modern techniques of instruction and methodology. Stressing the importance of modern curricula with assorted and non-monotonous means of training and evaluation, the Emirates launched ambitious campaigns to develop each of these areas. At its foundation lies the necessary funding, which in 2009 was earmarked at 7.4 billion dirhams (USD 2 billion), as well as increased teacher training. Through its Teachers of the 21st Century and a 200 million dirham share of this budget, the UAE hopes to train 10,000 public school teachers within the next five years, while also pursuing its scheduled goal of reaching 90% emiratization of its staff by 2020 (Bacsich, 2014).

In addition, the UAE government believes that a poor grasp of English is one of the main employment barriers for UAE nationals. As a first remedial step, the Abu Dhabi Education Council (ADEC) is developing an elementary school pilot programme with Zayed University, which it hopes to extend to all schools in the emirate, to enhance student English language skills. In February 2006, the prime minister directed the education minister to take initial steps toward improving the quality of education, including the provision of permanent classrooms, computer laboratories, and modern facilities. In April 2007, however, in a major policy speech to the nation (Library of Congress, 2007), the UAE's vice president and prime minister stated that despite the steady increase in the education budget over the previous 20 years, teaching methods and curricula were obsolete, and the education system as a whole was weak. This has also been seen through our visits, supervision, and consultancy to schools and teachers in different emirates. Therefore, the prime minister has demanded that the ministers of education and higher education work to find innovative and comprehensive solutions.

In early 2008, the UAE's Ministry of Education launched a Mentoring Programme which assigned Western principals to 735 public schools across the UAE in an effort to modernize instructional strategies and implement Western methods of teaching. Participating instructors' training emphasized the necessity of deviating from the traditional methods of passive memorization and rote learning, and instead encouraged active student participation. However, this Mentoring programme had a little impact, especially in improving science teaching and learing. As a result, a study by Makhmasi (National, 2012), a Master's engineering student at Khalifa University, investigated 1,000 private and government school and university students including Emiratis and expatriates, reported that the number of students choosing science, technology, engineering and mathematics is less than half those choosing the arts. In 2011, for every student that chose to follow a science career path, three chose to follow an arts-related career path. If this does not change it will be a problem for the UAE. Therefore, the aim would be to become an exporting country of knowledge and experts, not an importing one.

In light of this, the level of students' English in government schools is also a cause for concern. Students in private schools do not seem to have any major issues with English proficiency while English is problematic for students in government schools. In private schools, the English language is used as the medium for delivery of all the subjects, except the Arabic and Islamic studies, with ample opportunities for intervention. Therefore, most students in the private schools are proficient in the English language, while the majority of students in public schools lack adequacy in English language skills. In my observation of students and theiruse of the English language, students at private schools, (making about 70% of the population of students in the UAE), extend their use of the English language beyond the classroom to become the language of communication in the school with teachers and their peers, since they come from diverse backgrounds and the English language is considered the common language. This in turn makes it all but impossible to take a degree in science or technology for local students who complete their education in governmental schools, because such areas require more knowledge of English than others such as liberal arts and business. At many institutions in the UAE such as the United Arab Emirates University and the Petroleum Institute in Abu Dhabi, the students will stay in a foundation (remedial English) programme for the maximum of two years and still not make it to undergraduate stage, which may make them feel depressed and give them a sense of failure.

The Abu Dhabi Education Council (ADEC) and the Knowledge and Human Development Authority (KHDA) have long acknowledged this problem. A KHDA initiative of providing Post Graduate Diploma in Education (PGDE) degrees to interested mid-career professionals in science, mathematics and English was run for three years starting 2008 in conjunction with the British University in Dubai but it was postponed due to the shifting of authority from the KHDA to the Ministry of Education and a lack of clear strategic policy. To reverse the trend, in 2010, ADEC launched its New School Model based on bilingual teaching to better prepare students for university. By 2015 it is expected that all students in the capital's government schools will be taught science and mathematics in English.

Similarly, Malaysia started to teach science and math in the English language in 2003, mainly to improve the students' English language as a part of their future literacy in technology and science. In order to implement this kind of project, public school science teachers were trained on English language courses yet all of them used the Malay language to explain scientific concepts and the English language for science terminologies and vocabulary. According to Oun and May (2008) after research based on observation and feedback, three major factors were negatively affecting the outcome of the project: firstly the teachers' academic background, secondly the overall social and community environment within the school as well as outside, and thirdly the students' capacity to express themselves correctly and fluently in English. Other research done by Solan (2008) implies that teaching students in a second language in which they express difficulty will not enhance any learning or even any attainment. This is further expounded by Prytula and Weiman (2012) within the Singaporean context. They clearly explain that the vision of the Singaporean government to implement this kind of project was to help students express themselves in English once they attain higher grade levels and ease into their university years. It is known that to succeed in this kind of implementation, the content knowledge of the teacher is a first factor, as well as his or her English proficiency level, and finally the curriculum adaptation according to the new instructional language. Additionally, it should be mentioned that the urban and non-urban environments could play a crucial role in the outcome of the students as well as the proficiency level of the teacher. Such experiences are worth looking into as the UAE strives to benchmark its educational system with higher standards.

Kenneth Cadd, Head of the Institute of Applied Technology in Abu Dhabi, states that many pupils opt out of the sciences because of a "laid back attitude to education". He continues that around grade 8 or 9, there should be guidance for students to highlight the benefits of science-based programmes. Schools needed to be pushed to promote science subjects, as he believes that "schools should run 50 per cent art programmes and 50 per cent science programmes. And if they do not, then their funding should be reduced" (Swan & Ahmed, 2012, p.12).

SCIENCE TEACHER PROFESSIONAL DEVELOPMENT

Professional development, in a broad sense, refers to the development of a person in his or her professional role. More specifically, teacher development is the professional growth a teacher achieves as a result of gaining increased experience and examining his or her teaching systematically (Villegas-Reimers, 2003).

Extensive research is conducted on in-service teacher professional development (Altun & Taner, 2012; Bransford, 2009; Olofsson & Lindberg, 2011). A key aspect for teacher growth is to conduct the professional development by using models that call for learner-centred approaches. In a recent longitudinal study by Lee and Maerten-Rivera (2012), a series of curriculum units were developed that constituted the entire science curriculum for grades 3–5, which replaced the district-adopted curriculum in the six participating schools in the US to support (a) teacher knowledge of science content, (b) teaching practices to promote scientific understanding, (c) teaching practices to promote scientific inquiry, and (d) teaching practices to support English language development. The results from the questionnaire and classroom observations indicated some improvements in teachers' knowledge and practices in teaching science to English language learners (ELLs) over the intervention. The grade taught was the most pronounced predictor variable and distinguished the fifth grade, the grade at which science counted toward the state accountability policy. Despite improvements, teachers' knowledge and practices generally did not meet the goals of reform-oriented practices.

This study is considered important due to its methodology being a longitudinal study and its important dual purpose in improving science teachers' knowledge and transformation of practices as well as meeting the reform-oriented policies. Such experiences would be needed to positively impact on any science development in the UAE. However, a primary task would be to strategically plan a science reform document with adequate time for implementation and evaluation.

The professional identity of a teacher is central to competencies that teachers exhibit in action (Beijaard, Meijer & Verloop, 2004). Teacher identity is also important in recognizing teacher realization of strengths and weaknesses which may encourage intrinsic motivation in teachers to seek PD. Seeking PD is also dependent upon how teachers view themselves and the environments in which they work (Altun & Taner, 2012). Although much research focuses on the development of teacher identity in beginning teachers as they combine their past and their expectations into their professional lives, teacher identity is never linked to professional development. This point is important as the UAE cultural identity has a strong influence on the educational system and is reciprocally impacted by it.

Fwu and Wang (2012) identified that teachers tend to practise their craft as well as learn about their profession in isolation from their colleagues. Traditionally, teachers plan and teach their students in individual classrooms with the doors closed and without the involvement of others. This can be criticized as Slavin (2009) calls it ‘teacher on the stage and students on the siege’ meaning that the teacher is usually in control of the teaching environment including the students. Unless there were problems in the classroom or complaints from parents, the teacher was left alone to practise his or her craft largely uninterrupted. “Historically, schools have been structured so that teachers work alone, are rarely given time together to plan lessons, share instructional practices, assess students, design curriculum, or help make administrative decisions (Darling-Hammond, 2006, p. 11).

Research, however, has shown that teachers who engage in collaboration have improved perceptions of their own identities as well as satisfaction from their work (Day, Kington, Stobart & Sammons, 2006).Collaboration is a significant task, as it entails both a challenge to educational tradition as well as he structure of the school day. In order to effect change, administrators may be required to restructure the school time-table to facilitate opportunities for teachers to work collaboratively in a professional learning community. After this time has been made available, teachers may still need to be nudged in the collaborative direction and this may ultimately need to be the culture of the school. Changing the culture of a school is not an easy task, though, especially if the existing school culture and structures favour privacy and isolation (Darling-Hammond, Barron, Pearson, Schoenfeld, Stage, Zimmerman, Cervetti & Tilson, 2009).

Eilks and Markic (2011) lament teacher isolation, noting that little has changed, and claiming that isolation reduces the quality of the individual classroom teacher. One of the problems with working in isolation is that an individual teacher is not exposed to different ways of teaching and school dealings. In this regard, the teacher may begin to believe that his or her way of teaching and assessment is the only way or the best way of doing things. Another potential problem is that a teacher does not get to share the successes and struggles of his or her own experiences (Jacobsen, Eggen & Kauchak, 2006) or learn from the experiences of the other teachers in the school. Therefore, such a problem is determined by the level of collaboration and the type of school system (Kanold, Tonchef & Douglas, 2008).

UAE SCIENCE PROFESSIONAL DEVELOPMENT NEEDS

It is widely accepted that the development and welfare of countries mainly depends on the development of human resources. One of the most important factors playing a role in the development process is that of having an adequately qualified workforce. In this sense, having a qualified workforce depends on the quality of education and the quality of teachers in schools who will educate tomorrows’ citizens of the country (Altun & Taner, 2012). We considered this as a critical area for teacher development. Therefore, in this section, attention to such critical need of preparation and development is paid.

Current science education reforms in the UAE have focused, among other things, on the role of science teachers in shaping the future development of the country. The main theme of the UAE reform proposes promising policies for the future and professional development of teachers. Professionally developed teachers can, in return, inspire students to acquire scientific and technological literacy so that they can have better future choices, lifelong learning skills, and consequently better living standards. Indeed, this has proven to be a major challenge for current science education reform activities. To increase the science understanding of elementary level teachers while providing them with strategies and techniques for teaching science effectively to support and enhance their students' science understanding requires not only reforming existing programmes but also developing theory- and research-based knowledge for teacher education programmes. Thus, it is important to determine the extent to which science teacher education programmes focus on covering and developing scientific literacy among prospective science teachers and to assess how well these programmes effectively support the attainment of those specified learning goals.

Most development relates to an aspect that can be done only by and for oneself. Therefore, it can be said that in order to develop professionally, teachers should feel a continuous desire to learn more about themselves as professionals and about their profession. According to Eekelen, Vermunt, and Boshuizen (as cited in Soleiman and Khaliliyan, 2012, p. 363), "Self-directed professional development is defined as the professional development arising from the teachers' own initiative, i.e. the process is internally determined and initiated." Self-directed professional development has several advantages, such as allowing teachers to determine their own goals for professional development, the types of activities presented, strategies followed and timing and scheduling that best fit their interest and preference. Such PD opportunities are rare though, due to many inhibiting factors, such as school systems, workload, leave issues, and limited PD offerings. However, the benefits exceed the challenges when teachers develop their cognitive ability and metacognitive awareness as they focus on developing their own areas of shortcoming and become more reflective practitioners. As stated by Richards and Farrell (2005), self-directed learning is based on attitudes that encourage teachers to explore their own context and construct their own knowledge and understanding of what takes place in their classroom.

The UAE is striving to upgrade its citizens' knowledge, understanding, and career orientations so they can actively take part in the country's development and advance its policy implementation (Forawi, 2013). Based on previous experience and research, teachers' beliefs and acceptance of such reform agendas is a key success factor in policy implementation. In considering the UAE context, specific remedies of teachers' professional development should be noted: (a) teacher knowledge of science content, (b) teaching practices to promote scientific understanding, and (c) teaching practices to promote scientific inquiry in teacher professional development intervention.

The major problem that professional development has encountered is that it is usually developed as an isolated requirement, with no real connection to daily teaching and with almost no teacher input (Chambers, Lam & Mahitivanichcha, 2008; Varela, 2012). Varela also indicated that for US teachers, the new teacher evaluations and accountability procedures mean that teachers must, in turn, demand high quality professional development – development that helps mentor, nurture and enhance their professional repertoire. The reasons for professional development, however, vary in degree and kind. There is no clear accountability requirement except the hiring and firing process, based on contracts which lessen any motivation to seek professional development. Other obstacles as reported by teachers' questionnaire responses are: 1) heavy workload which does not leave room for professional development, 2) disconnected professional development activities, 3) a lack of embedded practices of the professional development, and 4) an absence of differentiated professional development experiences, as they are largely planned for all teachers, beginners and veteran, with the same objectives.

Science Teachers' Perceptions on Professional Development

The questionnaire was developed by the author for this chapter to measure participating teachers' perceptions regarding professional development issues as indicated in previous sections. Several sources were incorporated Teaching and Learning International Survey (TALIS) (OECD, 2013) and TIMSS (2014). The Teacher Professional Development Questionnaire (TPDQ) consisted of 26 five-Likert scale items and five open-ended questions written in English language for familiarity of teachers with English. A translated Arabic version of the TPDQ was prepared in case any school requires it for teachers which did not happen. The Questionnaire was piloted with 26 science teachers to test for reliability (Cronbach, 1951) which was found to be high, 0.85. The validity was also checked using a panel of five teachers who pursue master degree studies. The results of the questionnaire revealed several interesting perceptions that are considered a direct reflection on science teachers' experiences and challenges regarding professional development and they also map the reality of the hopeful model that is developed in this study to better suit the needs of science teachers' PD in the UAE.

First the demographics of participating teachers are presented. A total of 283 science teachers responded to the online TPDQ during its two rounds of call. Ninety eight participants were male (35%) while185 were female (65%), including 19% elementary (cycle 1), 46% middle (cycle 2) and 35% high school teachers from the total respondents. The majority of participants, that is, 58% of participants, were from governmental schools, while 42% were from private schools. Twelve nationalities were recorded, including Emirati, Indian, Egyptian, Jordanian, Syrian, Algerian, British, and Pakistani. The years of experience indicated by the majority of the participants were in the range of six to ten years; some had more years of experience and a few had less than four years of teaching experience. The second largest experience group was for those with more than 15 years of teaching experience. As for their ages, half of the participants fell between two age groups, 31–40 and 41–50. Equally, a small number of their ages fell beyond these ranges. The reported degrees held by participating teachers included bachelors (67%), masters

(21), and higher diplomas (19%) with different majors ranging from general science, biology, physics, chemistry, earth science, and others. General science and biology comprised the majority of teacher majors, 36% and 29% respectively.

Table 1 below presents a summary of the participating teachers' responses in the main items of the questionnaire. Unsurprisingly in this context, the majority of teachers (60%) indicated that there is an acute shortage of professional development opportunities presented to them. Despite that, most participating teachers indicated the importance of professional development in improving their content and abilities to maximize student learning. Overwhelmingly, teachers (96%) can see for themselves the importance of professional development opportunities, offered to them by the schools and the MoE, in advancing student learning. However, only 25% of participating teachers take advantage of such limited opportunities. This explains why teachers have indicated, in the interviews, several obstacles to having and attending PD activities, such as the heavy workload and long school days. Also, in another questionnaire item, only a small number of participating teachers (19%) stated that their schools have a professional library that can assist in their development and teaching quality; in spite of the fact that half of the participating teachers have regular and equal access to professional development programmes, forms, publications, etc. Such access was further explained, in the interviews, by the teachers' personal means such as the internet, and affiliate universities at which they are pursuing their higher degrees.

While schools generally determine the professional development that teachers may have, the majority of teachers do not indicate any notable discussion on professional development going on in their schools (5%) and only 10%indicated that they can get release if they apply for their own professional development activities that they mostly pay for themselves, and that the schools only grant them time release to attend, without financial support. This is a challenging issue facing teachers in the UAE, that there are limited opportunities and that there is a lack of support from authorities on any professional development occasions. Male teachers in the government schools are the most affected by this lack of professional development as they may need it the most due to the new educational systems that they are employed in, especially as they tend to be expatriate teachers coming from countries with different educational systems.

Most participating teachers (65%) preferred PD activities in multiple subject areas such as science content, teaching strategies, assessment, motivation and classroom management. They did not entertain taking professional development in only one area, e.g. content or strategies, as they preferred to take the PD in multiple areas collectively. This view relates to what the research suggests that teachers prefer comprehensive PD (Altun & Taner, 2012). Along the same lines, teachers overwhelmingly seemed to confuse their participation in developing curriculum and designing committees and see them as professional development.

Over half of the participating teachers (57%) attested that their schools include both short-term and long-term goals of professional development in their annual

Table 1. Participating teachers' perceptions

S.No	*Item*	*Response Rate%*
1.	There are enough opportunities offered to me by school or the Ministry to have professional development	40%
2.	I participate in the professional development provided to me	25%
3.	Professional development activities should be related to need of teachers in maximizing student learning	83%
4.	We have a professional library, in the school or accessible to us, stacked with professional books, magazines, video& audio tapes	19%
5.	Teachers can get release by the school/zone to attend if we submit proposals for individual professional growth	10%
6.	Our staff has ongoing discussion groups on professional development issues	5%
7.	Teachers have regular and equal access to professional development programmes, forms, publications, etc.	50%
8.	Our professional development approach has both long-range and short-term goals tied to our school improvement plan	57%
9.	Our professional development approach has only short-term goals tied to our school improvement plan.	67%
10.	Our school/zone has an annual plan that includes teacher professional development	41%
11.	The professional development activities I had focused only on content	24%
12.	The professional development activities I had focused only on teaching strategies	25%
13.	The professional development activities I had focused on content and teaching strategies, assessment, classroom management, &resources	65%
14.	Our school/zone establishes regular meetings and annual training for new members	56%
15.	I see my professional development through engaging in developing curriculum and designing programmes	61%
16.	I see my professional development through training and workshops provided by experts	92%
17.	Teachers and administrators set yearly professional development goals.	57%
18.	I model continuous upgrading of my own professional development and leadership skills.	38%
19.	I pursue a higher education degree to assist me to professionally develop myself	21%
20.	Would like to undertake more professional development activities	90%

plans. However, a large percentage indicated that their school links short-term goals for PD in their planning. This result can be explained by the fact that with the limited PD opportunities, schools connect such PD opportunities to only short-term goals usually related to teacher evaluation or classroom-linked immediate issues, e.g. upgrading the content or use of technology for certain teachers for particular problematic grades. Such PD activities are viewed by teachers, in the interviews, as a way to retain their jobs rather than to satisfy their interests and needs for appropriate PD. Also, there is a need for long-term goals for PD as supported by research (Lee & Maerten-Rivera, 2012). It is clear that both short- and long-term goals are needed for the appropriate planning of professional development.

Unsurprisingly, most respondents (92%) see their professional development to be through training and workshops provided by experts, while engaging in developing curriculum and designing programmes were seen as types of professional development. Despite presenting these invariant results, the majority of participating teachers (90%) still attest to the need for more professional development. Finally, some teachers reported that they have master degrees (21%) yet more teachers see this as a direction that they independently would like to follow to upgrade their professional growth.

The open ended section of the TPDQ included three questions regarding professional development expectations:

a. What are some of your expectations in getting professional development activities?
b. How do you relate such expectations to your teaching subject area and students?
c. Can you add any additional comments regarding your understanding of teacher professional development?

The responses to the open questions at end of the questionnaire were transcribed, prepared and analyzed (Ryen, 2002) to highlight the following main results:

1. Many expectations were stated for effective professional development, however the most common one were, e.g., improving science content knowledge, teaching strategies, assessment techniques, classroom management, critical thinking, ICT utility.
2. The PD on classroom practices, and not the theoretical ones, sought to be the appropriate PD activities. Therefore, a strong need for exemplary lessons and synopsis of activities of science instruction is indicated.
3. Physical science is found as one of the major areas of need for the PD.
4. Many believe that the content of the staff development programs will increase student learning and that any professional development should ultimately impact student attainment.
5. Participants indicated need to be involved in planning and deciding on the professional development activities by determining the topics and content.

6. Science education experts or department leaders can be the PD facilitators to credibly provide the PD activities.
7. Need to share teacher best practices regarding guided-inquiry instruction with specific inquiry topics and examples.
8. Elementary, middle and high school science teachers are equally be provided with few opportunities for PD during the school year, with focus on content and instructional strategies.
9. Instructional supervisors provide on-going, one-on-one support during the year, especially for high school science teachers.
10. The interdisciplinary approach for such PD activities should be planned to include integration of sciences as well as science and other subject areas.
11. It is suggested by the participating teachers that first of all the financial difficulties of schools should be resolved and the physical conditions of schools should be improved in order to sustain school improvement and teachers' professional development.

To discuss these responses in light of the chapter's framework that the PD is a necessary activities for teachers to improve content (Lee & Maerten-Rivera, 2012), instruction (Posnanski, 2010), assessment and varied and comprehensive workshops (Altun & Taner, 2012). Such workshop opportunities are seen beneficial if are delivered by science educators and senior department managers. An interesting response, however, that is different than what previous research has indicated is the 'financial difficulty' that permit teachers for taking PD workshops and training.

As for the interviews, several responses were provided by selected participants to further explain the study's results (Kvale & Brinkmann, 2009), shown in the following examples:

- Mainly hands-on activities, discussion, and collaborative grouping, or a mixture of them are among the most preferred PD delivery styles. 'I mostly prefer several delivery styles, such as hands-on, collaborative, online or/and a mix of practical types, rather than theoretical.'
- Interviewees briefly described some of the best professional developmentsessions that they have had. They included: 'implementing AP curriculum which was rich in hands-on activities and lab applications.' 'CPD course in Learning Disability as it helped to understand the difficulties of the students and what can be done for them.' 'Having fun with your parachute was the best, because it incorporated many practical activities and provided me with innovative ideas to apply.' '…I attended many workshops, but one I remember the most was a workshop that gave tips on how to teach mitosis and meiosis divisions through play, games and kinesthetic movement. I'm using them in my classes since that day, and my students, boys and girls, adore them.'
- When participants were asked what are some reasons for you not to attend and take professional development, responses included; '…if the PD activities are

irrelevant, impractical or do not meet my interest,' '…overloaded with work commitment, time constraint, and family commitment.'

Most of the interview responses above indicated the reasons for the successful PD activities as well as some challenges that may prevent science teachers in the UAE from taking them. The best workshops are thought to be those which provide applicable ideas and real classroom situations, as supported by Duran, Brunvand, Ellsworth and Sendag (2012). Particularly, they are the workshops that provide more strategies and techniques that the teacher can apply with the students.

UAE Science Teacher Professional Growth (STPG) Model

Based on the extensive review and data analysis of science teacher PD study presented in this chapter, a final goal is to propose a model for the UAE's teacher professional growth that is more contextual, effective, comprehensive, and student-centred. In this regard, the following steps are suggested:

- Strategic planning for overall K-12 science education that rests on the scientific literacy, inquiry instruction, and moral education.
- Development and implementation of in-school professional development.
- Participation of research-based professional development.

Teachers need a wide variety of ongoing opportunities to improve their skills. The science teacher PD model rests on the specific instruction provided to teachers to promote their development in a certain area of science curriculum and leadership. Such a model can be used as a tool by which policymakers' visions for change are planned, disseminated and conveyed to teachers. Several layers, as presented in the figure below, encompass the Science Teacher Professional Growth Model (STPG model) to appropriately lead to teacher ongoing development that is measurable, sustainable, and meaningful.

The STPG model (Figure 1 below) has three possible modes of planning and delivery: train-the-trainer, school-based, and self-directed. Train-the-trainer is more of standardized mode where a certain set of goals for professional development are chosen to be presented by experts in the area who will train/lead teachers or supervisors who in turn cascade the activities to other teachers. The school-based mode involves long-term goals set by the school as part of its continuous process of improvement (CPI). The personal, cultural, and self-directed professional development component involves the sole individual teacher's initiatives on growth that is planned for short-term goals by the teacher through different avenues, such as ongoing workshops, follow-up, case studying, reflective practice, observations, assessment of the teacher as learner, and utility of methods and activities that are likely to lead teachers to improve their practice as professionals. In our opinion these three modes should lead to an ultimate professional growth that is linked to several

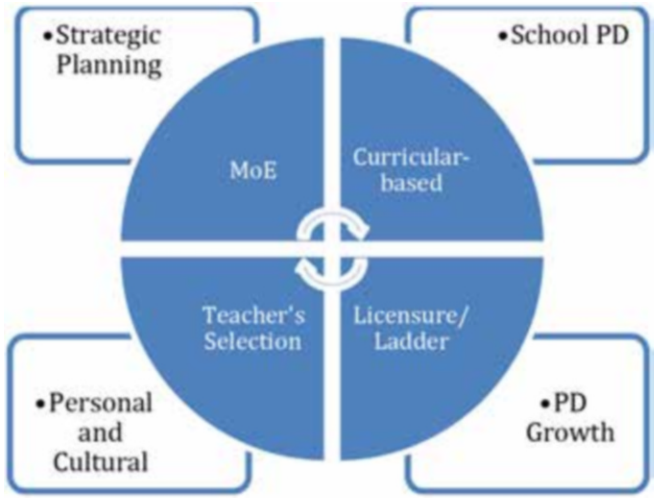

Figure 1. Science Teacher Professional Growth Model (STPG)

incentives, based on local needs, such as licensure, ladder upgrade, employment promotion, etc. This is important in the UAE context as the hiring authority, the Ministry of Education (governmental schools) and private schools, are in control of teachers' employment and that by linking such PD to such incentives, teachers can benefit the most yet get rewarded on any choice of available PD opportunities. Such a model takes into consideration the fact that there are limited PD activities teachers are allowed or asked to do. Therefore, this shared responsibility can itself be the force and motivation for greater growth. The idea of growth is also unique in the sense that any activity taken be teachers ought to lead to their growth, and consequently impact their students' learning and growth.

This PD model involves teachers in planning activities individually or collaboratively, when a master-teacher observes a beginning teacher and provides feedback; and when a team of teachers observes a video lesson and reflects on and discusses the lesson. Teacher involvement in planning and deciding on the professional development activities is a major component of the suggested model. Also, science educator and department chairs would be the most PD facilitators to credibly provide the PD activities. These aspects were evident in previous research review, which are echoed by participating UAE science teachers in the present study. The quadrants provide distinctive components with continual arrows that should be directed as those PD activities prevail. Finally, the model is based on both the present study's findings and research reviewed in this chapter, drawing in both theoretical and practical information in its development, yet should be further investigated in the UAE and other similar contexts.

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PART 2

THE REFORMS AND INNOVATIONS OF SCIENCE EDUCATION IN THE ARAB GULF STATES

ASMA AL-MAHROUQI

4. MAKING THE SCIENCE CLASS SPACIOUS FOR STUDENTS' VOICE

Dialogic Practice in Omani Science Classes

ABSTRACT

Researchers and professionals have very often characterized the dominating science teaching style in Oman as monologic lecture-based. The Omani educational system, as in many systems around the world, attempted to break away from this dominating style by emphasizing the role of students in constructing knowledge, and the role of the teacher in handing over to them the responsibility for their own learning. However, international research still refers to the under-representation of dialogic teaching practices where students contribute to the progression of their understanding by being given the chance to refine and work on their own ideas. This chapter delves under the surface of Omani science classroom interaction using the data of an empirical study that looked into levels of dialogic teacher-to-students talk. Analysis of the talk in the classroom was mainly based on further characterising the Authoritative and Dialogic communicative approaches of Mortimer and Scott (2003). After introducing the focus and context of the chapter, the second section focuses on dialogic characterisation of the classroom talk in the science and language literature. An overview of the Oman-based empirical study is then provided, and findings from one case are then discussed. The chapter ends by reflecting on these findings and suggesting implications for the teachers' professional development.

INTRODUCTION

Throughout the world, understanding of how learning is accomplished more effectively has gradually moved from traditional views of the learner as a passive participant, to constructivist views where learners actively participate and engage in the learning process. In Oman, the whole education system has been greatly influenced by this transition. By 1995, the Ministry of Education in Oman (MoE) had begun to shift its emphasis from quantity to quality of education by introducing the ambitious project of Basic Education, first applied in the academic year 1998–1999. Under this system, there is a great emphasis on the student-centred approaches to teaching and learning (MoE, 2004b).

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 71–95.

According to the MoE documents, the curricula for different subjects have been developed to emphasize the adoption of scientific thinking and modern technology. Also, the learning materials have been designed to enhance the students' ability to find, use, and understand, rather than memorize. Their content has been developed from being overloaded with theory and abstract concepts to be "based on practical and real-life contexts and applications, and provide students with opportunities for experiential learning" (MoE, 2006, p. 102). The MoE claims that the teacher-centred approaches to teaching and learning tended to be dominant in the old education system which was believed to lessen the participation of students in the teaching and learning process. This encouraged them to become passive learners expecting the teacher to tell them what and when to learn (MoE, 2004a). It was decided, therefore, that the Basic Education programme should support a student-centred rather than a teacher-centred approach. It should also avoid overuse of traditional methods of narration, lecturing, student recitation and rote learning, and respect the students' right to express opinions, ask questions and voice their personal experiences (MoE, 2001, p. 44). In response to these requirements, teaching science has been planned to be collaborative and activity/inquiry-based that targets communication, thinking and learning skills, so the classroom takes on a new approach that is more interactive and cooperative (MoE, 2004a, 2006).

However, international research shows that a student-centred teaching and learning approach is in place in many educational systems around the world. In spite of this, it refers to the under-representation of those teaching practices where students contribute to the progression of their understanding by being given the chance to refine and work on their own ideas (Alexander, 2000, 2004; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Nystrand, Wu, Gamoran, Zeiser, & Long, 2001; Skidmore, 2004, 2006; Wells, 1999). Lemke (1990) has also claimed that a large part of the classroom talk (henceforth CT) is just conducted to maintain the social structure of the teacher/student relationship, as students are not involved intellectually in building 'the scientific story' (Mortimer & Scott, 2003). Alexander (2008) summarises the situation, stating strongly that:

> Talk which in an effective and sustained way engages children cognitively and scaffolds their understanding is much less common than it should be. Teachers rather than learners control what is said, who says it and to whom. Teachers rather than learners do most of the talking. And, as many UK and US researchers have consistently found, one kind of talk predominates: the so-called `recitation script' of closed teacher questions, brief recall answers and minimal feedback which requires children to report someone else's thinking rather than to think for themselves. (Alexander, 2008, p. 93)

It is commonly agreed how critical and important the quality of CT is to students' learning and developing understanding, implying consequently that certain types of talk need to be prompted in teaching practices. Reflecting on the Omani context from my experience as a physics and senior science teacher, I developed a research interest to look into Omani science classes to examine the quality of CT taking place: what are its features? Does it entail dialogic practice? To what extent does it reflect a student-centred approach? What are the roles of teachers and students?

Consequently, in 2008 I conducted an empirical investigation observing the discursive interaction in Omani science classes and following its impact on student learning. The study developed to look not only into the Omani practice in terms of how dialogic it is, but to also investigate the dialogicity of CT itself (i.e. what is dialogic talk and what is it not? What are the characteristics of CT to be judged as dialogic or not? Does it differ in how dialogic it is, and if so, how?). This is in order to contribute to the theory of dialogicity in the science education literature.

The full report of this study can be referred to in Al-Mahrouqi (2011, 2010), and a brief review of some results on student learning can be found in Al-Mahrouqi& Scott (2012). In this chapter, I have chosen only to focus on the part of the findings concerning the quality of the discursive interaction observed in Omani science classes in terms of how dialogic or authoritative it is. Before delving into the details of these findings, I briefly consider dialogue and dialogic practice in language and science education research, to get a sense of the context of this study in the educational literature.

DIALOGIC IN LITERATURE

Chronologically, and by means of different approaches to discourse analysis, the quality of interaction has been conceptualized into different categories. In some studies from the sixties and before, the quality of interaction has been described as: Integrative/Dominative (Anderson, 1939), Democratic/Authoritarian (Lewin, Lippitt, & White, 1939), Student-centred/Teacher-centred (Withall, 1949), Inclusive/Preclusive (Cogan, 1956), and Indirect/Direct (Flanders, 1967), for example.

A persistent finding in those studies is that monologic, traditional, dominative, authoritarian, teacher-centred, preclusive and direct approaches dominate the teaching practice, although these are claimed not to be supportive of students' learning. However, Nystrand (1997), Nystrand et al. (2001) and Alexander (2000, 2004), argue that traditional paradigms of teaching could, in some cases, achieve the desired learning outcomes.

Part of the work on the quality of CT was focused on the 'dialogic' characterisation. In essence, 'dialogue' is more than a merely verbal exchange of words. It is an exchange of meanings where ideas are shared, discussed, elaborated, reflected on and developed. With this meaning, the word 'dialogic' has been largely used to label episodes of talk as well as to describe the dynamics of instruction in language and science classrooms. In many cases, defining dialogic talk or dialogic approaches to teaching, was to be assigned to a certain meaning and contrasted with an opposite one within the duality of dialogic as opposite to monologic (e.g. Nystrand, 1997; Nystrand, Wu, Gamoran, Zeiser, & Long, 2001), or dialogic in contrast to authoritative (e.g. Mortimer & Scott, 2003; Scott, Mortimer, & Aguiar, 2006). Most frequently in the studies concerned, there is no obvious distinction between the two, so the approaches to teaching would be described as dialogic or not aligning with the categorization of the dialogicity of different events of talk throughout this teaching.

For example, Wells (1999) talked about dialogic inquiry, where students can contribute to the progression of a community understanding of the topic in discussion. For him, this happens when the students go through 'progressive discourse' in which they are allowed to refine and work on their ideas to generate a general understanding. Likewise, Alexander (2004) assigned the concept of 'scaffolded dialogue' to his model of dialogic teaching, defining this concept as lying along the line "between 'transmission' and 'discovery' approaches (telling children as opposed to encouraging them to find out for themselves)" (p. 526).

For others, describing approaches to teaching as dialogic would follow, simply, the frequency of talk that has been categorized as dialogic according to some methodological scheme. For example, Nystrand (1997), and later on Nystrand et al. (2001), set a scale, according to which, episodes of talk from investigated English and Social Studies classes would be classified as dialogic or monologic (Table 1). For those events of talk classified as dialogic, the instruction would be described as dialogically-organized and vice versa.

Table 1. Monologically vs. dialogically organized instruction (Nystrand, 1997, p. 19)

Features	*Monologically Organized Instruction*	*Dialogically Organized Instruction*
Paradigm	Recitation	Discussion
Communication model	Transmission of knowledge	Transformation of understanding
Epistemology	Objectivism: knowledge is a given	Dialogism: knowledge emerges from interactions of voices
Source of valued Knowledge	Teacher, textbook authorities: excludes students	Includes students' interpretations and personal experience

One of the prominent contributions on the dialogicity of the discourse interaction is the work of Mortimer and Scott (2003) on the 'Communicative approach'. The communicative approach (CA) categorizes the talk between teacher and students along two dimensions. The first dimension represents two forms of interaction, dialogic and authoritative, whilst the second dimension involves the distinction between interactive and non-interactive talk. For the first dimension, dialogic communication involves the teacher and student talk being open to more than one point of view and there is exploration or 'interanimation' (Bakhtin, 1981) of ideas. In general terms, dialogic talk is open to different perspectives. On the other hand, authoritative communication is focused on just one point of view (usually the school science view) and there is no exploration of different ideas. For the second dimension, the talk can be interactive in the sense of involving the participation of more than one person, or non-interactive in the sense that one person is giving the talk, which is usually the teacher. These two dimensions combine to generate four classes: Interactive/dialogic, Non-interactive/dialogic, Interactive/authoritative and Non-interactive/authoritative (Figure 1).

Figure 1. The four classes of talk in the CA

The CA provides a methodological tool to classify CT into different types following a specified criterion; that is, the authority of the teacher. When analysing different case studies of teaching sequences, Mortimer and Scott (2003) and Scott et al. (2006) illustrated a shift in using the four communicative classes. Scott et al. (2006) investigated this shift. They argued that there is a tension between the dialogic/authoritative and interactive/non-interactive classes, describing it as "an inevitable part of teaching whose purpose is to support meaningful learning of scientific knowledge" (p. 605). In their view, dialogic teaching should include a movement between the different classes of talk. This means that in dialogic teaching, there is no preference of one type of interaction over the other because each one can have a function in a certain context.

In view of its potential, I decided to implement the CA as a methodological tool to characterize CT. However, an in-depth discussion of its features and use raised the need to develop a broader analytical framework of discourse analysis to further characterize the authoritative and dialogic communicative approaches. The next section provides more details on the methodology of the study.

OVERVIEW OF THE OMAN-BASED EMPIRICAL STUDY

The empirical study referred to above was carried out with the broad aims of characterising the talk in Omani high school science classes and exploring the nature of any links between the quality of this talk and student learning. In outline, the project involved the author working with four science teachers and their grade 9 classes in a girls' high school. The research project was developed in two stages with the first stage focussed on the teachers' existing practices by analysing the CT taking place. After completion of Stage 1 the participating teachers followed a short training intervention, led by the author and designed to promote the practice of more dialogic talk in teaching. The intervention focused on the importance of involving students' ideas and experiences in science learning, and how such ideas are to be incorporated through a dialogic form of teaching. Different activities (e.g. questionnaire, handouts, presentations, group discussions) were utilised. It included activities that drew attention to the theme of students' prior knowledge and its influence on teaching and learning, proceeding by presenting the ideas of 'Learning Demand' that the teacher needs to address to help the students develop the required understanding (Leach & Scott, 2002) and CA (Mortimer & Scott, 2003) with a greater focus on dialogic talk.

In Stage 2 the classroom practices of the teachers were once more scrutinised. The Stage 1 lessons involved a short teaching sequence on Physical and Chemical Changes whilst the Stage 2 lessons focussed on Electric Circuits. All of the lessons were video-taped and the spoken interactions were transcribed.

In the first stage of analysis, the different kinds of CT were linked to the four classes of communicative approach developed by Mortimer and Scott (2003). After the full lesson transcripts of CT were classified into the four communicative classes, a large number of examples were selected from each lesson at each stage to go through a detailed characterisation using the developed framework of discourse analysis.

An extensive account is needed to explain the methodology of the study, especially the training intervention and the discourse analysis framework that both comprise many and varied details. Due to the limited space however, the chapter puts its focus only on characterising the different communicative approaches observed, by presenting some findings from one case, from the two stages before and after the intervention.

Findings from One Case

Here I report the findings from just one case of one teacher working with one class across both Stage 1 ('normal practice' prior to the intervention) and Stage 2 ('refined practice' after the intervention). The data offered enough examples of talk from both the authoritative and dialogic talk, whilst maintaining the same combination of teacher plus students.

First Stage before the Intervention

Figure 2 presents the results from the first stage lessons on 'Substance changes'. The classification of CT into the four classes of the CA shows teaching being dominated by the authoritative communicative approach. Apart from 55 seconds of interactive/dialogic talk taking place in Lesson 3, the CT time is all spent in interactive and non-interactive authoritative talk. The next step of the analysis was to use the developed analytical framework to further characterize the observed communicative approaches. Results from different examples of talk revealed general characteristics of the authoritative type that have been noticed repeatedly. These are:

The dominance of the evaluative voice of the teacher. When examining the exemplified episodes of talk, the evaluative voice of the teacher was found to be always there, providing an immediate evaluation for the students' contributions. She was approving the ones considered by her as scientifically correct and disapproving of the ones deemed incorrect. The result was a continuous evaluative follow-up moves through the patterns of discourse. Whether approving or disapproving of the students' responses, the teacher's authoritative voice emerged in her firm, strong and direct evaluation as demonstrated by different examples:

R: The colour / F: The colour, good (R: Response – F: Follow-up)
R: Melting / F: Instead of melting, I say melting point

This evaluation was not confined to the words of agreement and disagreement only but it also revealed itself through the teacher's reactions in the form of intonation and body gestures. In many cases, she did not approve or disapprove of the uttered answers explicitly. She just repeated those answers with an affirming intonation (^) indicating her agreement, and a wonder tone (?!) for disagreement. This can be noticed in most of the examples of this stage:

S_1: Calcium chloride / T: With calcium chloride^ (S: Student – T:Teacher)
S_5: The rising of bubbles / T: Bubbles rose?!

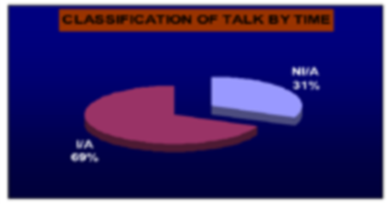
The teacher's continuous evaluation of students' responses manifested itself in a continuous replication of the conventional sequence of authoritative talk (Initiation-Response-Evaluative follow-up, I-R-E_v) throughout the patterns of discourse. Most of the examples of this stage show this feature, and it is striking to see the persistence of this sequence through long episodes of talk, as the following patterns illustrate:

$I\text{-}R_{1.1}\text{-}E_v\text{-}R_{1.2}\text{-}E_v\text{-}I\text{-}R_2\text{-}E_v\text{-}R_3\text{-}E_v\text{-}R_4\text{-}E_v\text{-}R_5\text{-}E_v\text{-}R_{6.1}\text{-}E_v\text{-}R_{6.2}\text{-}E_v\text{-}I\text{-}R_g\text{-}E_v\text{-}I\text{-}R_7\text{-}E_v$
$I\text{-}R_{1.1}\text{-}I\text{-}R_{1.2}\text{-}E_v\text{-}I\text{-}R_{1.3}\text{-}E_v\text{-}I\text{-}R_{1.4}\text{-}E_v\text{-}R_{1.5}\text{-}E_v\text{-}I\text{-}R_{1.6}\text{-}E_v\ldots$

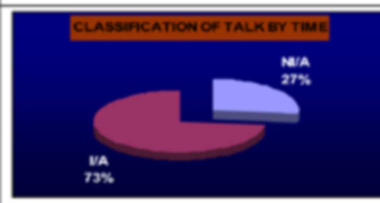
Time/Ratio of each class	Graphical representation

Lesson 1 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minute	7:56	17:16	0	0
Percentage	31 %	69 %	0 %	0 %

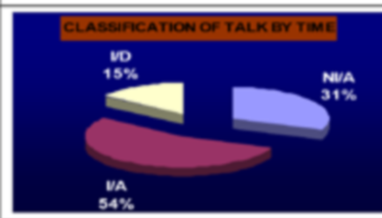
NI/A: Non-Interactive/Authoritative
I/A:Interactive/Authoritative – I/D:Interactive/Dialogic
NI/D: Non-Interactive/Dialogic



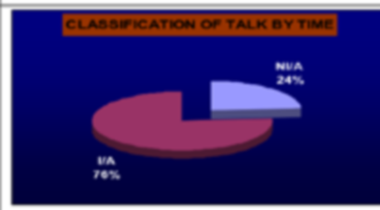
Lesson 2 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	4:28	12:20	0	0
Percentage	27 %	73 %	0 %	0 %



Lesson 3 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	1:55	3:20	0:55	0
Percentage	31 %	54 %	15 %	0 %



Lesson 4 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	7:14	23:16	0	0
Percentage	24 %	76 %	0 %	0 %



Lesson 5 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	10:02	16:18	0	0
Percentage	38 %	62 %	0 %	0 %

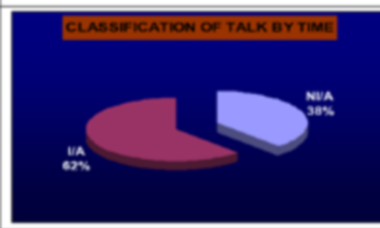


Figure 2. The results of CT classification, Stage 1

It is also interesting to find that in some incidents, the teacher used the questions of the initiation move to practise the evaluative role. It happened that after some initiations had been answered, and their answers were being evaluated, the teacher was repeating the same question. At other times, she was rephrasing the posed question by approaching it from a different angle. Through both strategies, the teacher aimed to affirm the uttered answer indirectly by stimulating the students to utter it again. The following excerpt demonstrates this use:

25:T	…But still you've not proved why it's physical change? Yeah S_7	I
26: S_7	'Cos the precipitate in the filter paper can be returned back to the glass #	$R_{7.1}$
27: T	Very good,' cos I can reverse the step and I'll get the same previous result. So, it's a physical change, why? One of you say it again.	E_v I
28: S_8	Cos the precipitate can be returned back to its original state.	$R_{8.1}$

Here, the teacher asked for a justification through the initiation (I) in turn 25, got a response (R), and evaluated it (E_v) positively in turn 27. In the same turn, however, she repeats the question again to get the same answer. Therefore, the initiation in turn 27 can be considered as part of her evaluative voice.

The movement of the talk towards the scientific view. The dominance of the evaluative follow-up move indicates that the teacher was aiming to move the talk only towards the scientific point of view. In doing so, the teacher employed different strategies of using the initiation move. In one extract for example, the teacher used the questions related to empirical content to ask 'Did certain observations happen' rather than 'What happened'. Such questions had imposed responses of the type of 'Yes/No' and the 'One from two choices' answers:

I: Did…(it) dissolve? / R: No (I: Initiation – R: Response)
I: Have you noticed…colour? / R: No
I: This …didn't dissolve,…(that), was how before? / R: Dissolved
I: …Rough or Soft? / R: Rough

This illustrates that by restricting the students' answers to highly-defined alternatives through very close-ended questions, the teacher was not only leading the talk towards the scientific views, but towards highly-defined ones in fact.

1.T	…What's the reason? Or what are the errors?	I
2.S_1	Maybe the way we put the filter paper is wrong.	R_1
3.T	Good, maybe you didn't put the filter paper in the right way, S_2	F
4.S_2	The filter paper hasn't been folded in a right way.	R_2
5.T	Yeah, folding the filter paper in the wrong way, what else? S_3	F, I
6.S_3	Maybe the shaking of the solution?	R_3
7.T	It does nothing with the shaking. Even after the shaking, the solution separates, huh? During the pouring of the solution, maybe you did it quickly and some leaked out at the back of the filter paper and I said pour it slowly. So what do you do in this case? – I will repeat the filtration again…	F

It can be seen from the excerpt above that the nature of the question, as open ended, has not allowed students' contributions to move towards certain assumptions as sources of errors. Instead, there were different contributions from them that the teacher might have not thought of. However, the teacher insisted on setting the scientific direction through the follow-up moves (F). She did this by: evaluating the students' contributions, whether approving (turns 3 & 5) or disapproving (turn 7); not elaborating the students' responses ($I-R_1-E_v-R_2-E_v-R_3-E_v$); having one specific error in her mind (see turn 7) in that she asked the groups to repeat the filtration process by paying attention to that particular error and neglecting the ones they offered.

The absence of the neutral and the challenging voices of the teacher. Throughout the examples of this stage, the absence of comments (C_0) and elaborative follow-ups (E_L) has been widely noticed. For most of the questions, the teacher was evaluating the students' responses instantly without showing a neutral reaction (comment C_0) that could give them a chance to think about the presented answers or might have encouraged them to doubt those answers or offer different views. Moreover, the talk rarely witnessed the teacher asking them elaborative questions of 'how' and 'why'. The quantitative representation of the types of follow-ups (E_v, C_0 or E_L) as obtained from the framework application illustrates this feature. Table 2 demonstrates the dominance of the evaluative moves against the almost absence of the comments and elaborative follow-ups:

Table 2. Comparison between 'follow-up' types in I/A excerpts

Examples of Authoritative talk	*Types of follow-up*			*Examples of Authoritative talk*	*Types of follow-up*		
	E_v	C_0	E_L		E_v	C_0	E_L
Les.1, Auth.1	9			Les.4, Auth.2	8		
Les.1, Auth.2	10			Les.4, Auth.3	10		
Les.3, Auth.1	3			Les.5, Auth.1	3		
Les.3, Auth.2	4			Les.5, Auth.2	2	2	
Les.4, Auth.1	11		3	Les.5, Auth.3	2	1	

The teacher's high controlling attitude in many examples in this stage is obvious and results in a lack of justification questions. In one lesson, for example, she began explaining stalactites and stalagmites and the natural phenomenon of how they develop. This information was an extension of information presented in previous lessons. During this talk, she asked the students about the substance forming as a result of the reaction of calcium carbonate with acid rain; a question considered of a high cognitive level:

T	Anyone know the name of this substance? …as a result of the reaction of the calcium carbonate with the acid	I
S_5	Potassium chloride	R_5
T	We're saying calcium and she is going to potassium chloride. Of course no,' cos we're talking about something with calcium. S_6	F
S_6	Calcium chloride	R_6
T	No	F
S_5	Sodium chloride	R_7
T	Why sodium? Have we mentioned anything about sodium? Have we mentioned potassium?	F
S_8	Calcium nitrates (T is nodding no)	R_8, F
S_9	Calcium bicarbonate	R_9
T	Calcium bicarbonate. Excellent, listen to her. The substance forming here is calcium bicarbonate…	F

The excerpt shows four students trying to guess the substance forming as a result of the reaction, but they fail to provide the correct one. Then S_9 offered the correct answer of calcium bicarbonate, which pleased the teacher immensely that she approved it instantly and strongly. However, she did not try to elaborate on it by asking S_9 for any explanation on how she got to this answer, which is extremely difficult to be imagined as a guess.

The verbal and the intellectual control of the teacher over the explanation task. A significant reason for the absence of the elaborative voice is the teacher's control over the explanation task. As explained earlier, in most of the examples the teacher was guiding the students to offer mere possibilities and exact answers. She was not directing extension questions where students would have to provide justifications and explanations for their answers. She kept this role for herself; explaining some answers and/or raising controversial issues about others. In some incidents, she did so through follow-up turns within the (interactive/authoritative) parts. Let us look, for example, at the students' responses and the teacher's reactions in the following excerpt:

S_1	The colour
T	The colour, good. But we need to pay attention to something here. Right, colour is a physical property but also can be? Chemical property. So I wouldn't take it now as a distinctive one, OK? S_2
S_2	We can say melting
T	Instead of saying melting, I say melting point. It's a physical property, why? Well done. I mean girls, if the substance was melting and then went through a freezing phase. Can't it be returned back to its first state? Yeah it's possible, you get it? S_3

Here, the teacher was doing most of the talking, hence holding verbal control over the explanation task. This resulted in long turns for her, through which she was also controlling the talk intellectually by directing the thinking of the students. Thus, she not only disallowed the students to speak out their own thoughts, but she also imposed her own ideas on their thinking. In many other incidents, she used (non-interactive/authoritative) approaches to lecture about the views raised through the interactive talk. In one example (below), the teacher used her follow-up to raise some thoughts regarding the water cycle, dissolving processes and the formation of metals. She then responded herself to these points which resulted on her dominating the talk verbally for a long time.

S_7	The water cycle
T	The water cycle in nature, what kind of change? Physical. This is of course if there is not any kind of chemicals that dissolve in water when it rains. For example, acid rain happens when we have acidic substances dissolving in rain water, then we will have an acid rain. This is a different case, but the normal water cycle in nature is considered what? Physical change. Here you said the dissolving of salt. The dissolving of substances. Dissolving of salts in general is considered…The forming of metals…the different kinds of forming that happens in the crust of the Earth are considered physical changes…

In conclusion, this was a brief description of the distinctive characteristics that were noticed repeatedly in all the authoritative talk. Interestingly however, the varied examples appeared to show different levels of authority. These features looked less persistent and less evident in some examples than in others. This resulted in viewing the authoritative type of talk along three general levels of high, mid and low, instead of the one level that is conceptualised in the CA of Mortimer and Scott (2003). It is not the place here to detail this advance of conceptual frameworks and the differences in characteristics between the three levels. However, a detailed description of this ‘multi-level’ communicative approach can be found in Al-Mahrouqi (2011, 2010).

SECOND STAGE AFTER THE INTERVENTION

Figure 3 presents the results from the second stage for the Electric Circuit lessons, which witnessed a big change in the communicative approaches. The results indicate that out of the five analysed lessons, three demonstrate high percentages of dialogic talk. For instance, dialogic communicative approaches prevailed in 90% of the talk time in lesson three. Applying the analytical framework of discourse analysis, the detailed analysis of dialogic extracts also revealed distinctive features of this type of talk. These are:

The substitution of the evaluative position of the teacher with a neutral one. A very distinctive feature that differentiates a dialogic excerpt from an authoritative one is the absence of the evaluative voice. Alternatively, the teacher takes a neutral stance in responding to the students' contributions. In the entire dialogic examples analysed, the teacher was neither approving nor disapproving of the students' presented views. She was just commenting by repeating, restating or rephrasing them. The quantitative representation of the types of the follow-ups (Table 3) illustrates the total absence of the evaluative move (E_v) in favour of the comment one (C_0):

Table 3. Comparison between E_v and C_0 in I/D excerpts

I/D Excerpt	*Follow-up*		*I/D Excerpt*	*Follow-up*	
	E_v	C_o		E_v	C_o
Les.2, Part 1	0	3	Les.3, Ex.2, Part 2	0	4
Les.2, Part 2	0	2	Les.3, Ex.3	0	3
Les.2, Part 3	0	2	Les.4, Part 1	0	1
Les.2, Part 4	0	4	Les.4, Part 2	0	1
Les.3. Ex.1	0	5	Les.4, Part 3	0	1
Les.3. Ex.2, Part 1	0	1			

On the whole, it can be said that the teacher used the follow-up comment to perform two divisions of functions: a) to direct the attention of the class to the presented ideas, give these opinions value and encourage others to also speak out their thoughts; and b) to give the signal that the participation of a certain student or the discussion on a certain opinion should stop at that point.

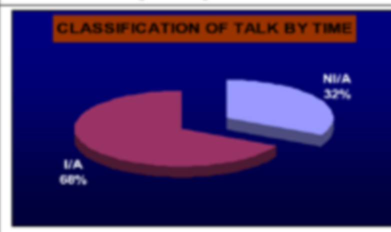
At the simplest level, the talk was taking the sequence of (I-R-C_0). This means that in practising the dialogic talk, the teacher was listening to a certain opinion without agreeing or disagreeing with it. She only provides a neutral comment that gives the impression that the view might be correct and would be taken into consideration. The excerpt below demonstrates this feature (I-R_3-C_0-I-R_4-C_0):

T	…What forms of energy are given out by the electric bulb?	I
S_3	Light	R_3
T	Light. other opinion?	C_0, I
S_4	Light and heat	R_4
T	Light and heat	C_0

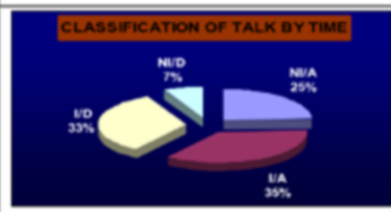
Time/Ratio of each class	Graphical representation

Lesson 1 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minute	6:07	12:46	0	0
Percentage	32 %	68 %	0 %	0 %

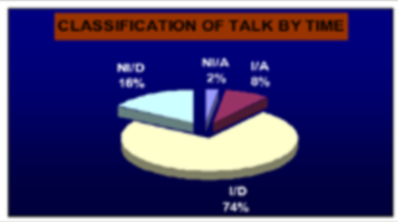
NI/A: Non-Interactive/Authoritative
I/A:Interactive/Authoritative – I/D:Interactive/Dialogic
NI/D: Non-Interactive/Dialogic



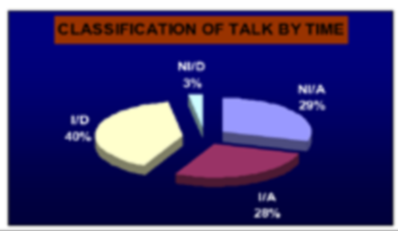
Lesson 2 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	8:19	11:56	11:12	2:27
Percentage	25 %	35 %	33 %	7 %



Lesson 3 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	0:30	1:50	16:00	3:37
Percentage	2 %	8 %	74 %	16 %



Lesson 4 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	9:04	8:34	12:21	0:51
Percentage	29 %	28 %	40 %	3 %



Lesson 5 (time of teacher-pupil talk in each class)				
Class of talk	NI/A	I/A	I/D	NI/D
Time in minutes	14:38	16:38	0	0
Percentage	47 %	53 %	0 %	0 %

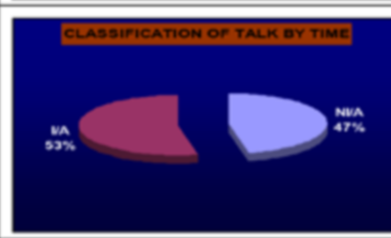


Figure 3. The results of CT classification, Stage 2

At a higher level, the teacher was asking the students more questions on the views they were presenting. She was listening to a certain opinion and then elaborates it (E_L) for a certain purpose (e.g. diagnosing, clarifying) before commenting on it (C_0).

Without any evaluation of the first opinion, she might then move on to a second opinion to do the same, and so on. Here is a small excerpt demonstrating this feature ($I\text{-}R_{7.1}\text{-}E_L\text{-}R_{7.2}\text{-}C_0$):

T	Now, what's the source of this energy? …	I
S_7	…From the things inside the resistance.	$R_{7.1}$
T	Comes from things inside the resistance, what's inside the resistance?	E_L
S_7	(…?) From the wires inside the bulb	$R_{7.2}$
T	So you say, the energy comes from the wires inside the bulb.	C_0

In other incidents, the teacher was further elaborating one student's view by questioning her successive responses, which resulted in longer exchanges of talk with each student. Consequently, the teacher's neutral comment on the student's view(s) comes at the very end of the dialogic excerpt. The example below provides an illustrative example ($I\text{-}R_{10.1}\text{-}E_L\text{-}R_{10.2}\text{-}E_L\text{-}R_{10.3}\text{-}E_L\text{-}R_{10.4}\text{-}E_L\text{-}R_{10.5}\text{-}E_L\text{-}R_{10.6}\text{-}C_0$):

T	Yes $S_{10,}$ What do you think?	I
S_{10}	The battery gives an electric energy and it passes through the wires.	$R_{10.1}$
T	How does it pass it through the wires?	E_L
S_{10}	'Cos the wires are connected to the electricity, the electrons will move through.	$R_{10.2}$
T	You said that the battery gives the circuit an electric energy, how?	E_L
S_{10}	'Cos it has chemical substances that help producing an electric energy. So the electrons will move through the wires till they reach the bulb	$R_{10.3}$
T	OK, I agree that the battery gives the circuit electric energy. Then you said the electrons will move through the wires. Where is the link between them?.	E_L
S_{10}	'Cos everything in life has energy, so the energy in the battery will move through the wires #	$R_{10.4}$
T	So the energy has the ability to move through the wires?	E_L
S_{10}	Yeah, it moves, yeah.	$R_{10.5}$
T	OK, why did you say the charges here?	E_L
S_{10}	'Cos the energy is made up of charges	$R_{10.6}$
T	Energy is made up of charges. Let's write your answer. And then the energy will move through the wires. The energy has the ability to move and so …	C_0

In most of the incidents of taking the students' views on a particular point, the teacher ended the Interactive/Dialogic parts by reviewing those views through Non-Interactive talk. In such incidents, she was controlling the talk verbally but not intellectually because she was neither contributing further scientific information nor evaluating students' opinions. She was only providing a summary of the presented opinions and thoughts in an attempt to ensure the entire class had an understanding of what has been shared. Here is one example:

T	All the positive and negative charges pass. That's enough for now. We've heard different opinions. Some are saying that the battery is the source of the charges and passes these charges to the wires. And the wires are conductive for the movement and so the bulb lights. This is basically the opinion of S_5, but S_7 said No, the wires have charges…

The openness of the teacher to the students' thoughts. All the Dialogic examples were built on the students' opinions. In some examples, these opinions appear to be discussed in more depth than in others. This openness appeared through the different moves of initiation, response and follow-up. Right from the beginning, the teacher made it clear that she wanted to hear the students' ideas regarding different issues of discussion. For example:

T	…you said that when closing the circuit, the bulb lights? I want to know, [from when] I close the switch till the bulb lights, how long it takes? Does it take a short period of time or a long one? Or will it light instantly? Yes, $S_{1.}$

She was also stimulating the students to present more ideas about these issues by asking continuously for other opinions:

T	…What do you think? She is telling us that the charges are coming from the wire?

Further, she was stimulating the students to offer views that contradict the ones presented already:

T	Is there anyone who disagrees with the description of the path of the current?

Sometimes, she was inviting the whole class to evaluate the presented contradictory opinions by voting for the one they think is correct or to offer a new opinion if not convinced with those ones:

T	OK. Let's see how many of you agree with S_1? 12. Ok. How many support S_2? 13. What about the rest of you?

In response to the teacher's initiations, the students' contributions to this dialogic talk differed in their length, quality and students' certainty of them. In some cases, the students' contributions were short, and limited to providing only the possibility they thought of without explaining the justification behind it:

T	.I want to know, [from when] I close the switch till the bulb lights, how long it takes?.	I	
S_1	Instantly.	$R_{1.1}$	
T	You mean at the moment we close the circuit, the bulb lights? *S_1 is saying instantly. Write her answer.	F $R_{1.2}$, F	*S_1 is nodding yes.

In other cases, however, the students' contributions extended into a long exchange of talk. Here is an excerpt that goes on from turn 11 to turn 35 with only one student: I-$R_{2.1}$-I-$R_{2.2}$-E_L-$R_{2.3}$-E_L-$R_{2.4}$-E_L-$R_{2.5}$-E_L-$R_{2.6}$-E_L-$R_{2.7}$-E_L-$R_{2.8}$-E_L-$R_{2.9}$-R_3-E_L-$R_{2.10}$-E_L-$R_{2.11}$-E_L-$R_{2.12}$-C_0.:

11.T	What do you think, S_2?	I
12.S_2	Maybe the charges are basically moving on their own from the beginning.	$R_{2.1}$
13.T	Do you agree or disagree with S_1?	I
14.S_2	A little (). Basically it has – the charges are moving there from the beginning.	$R_{2.2}$
15.T	Where do they move?	E_L
16.S_2	They move in the wire^ and go to the bulb.	$R_{2.3}$
17.T	So when the circuit is opened, the charges are moving?	E_L
18.S_2	No, it's not they're moving. I mean it must – once the switch is off, the charges will meet together and complete the movement around. They move around, but. They move around – they don't move around in the wire …	$R_{2.4}$
21.T	…They're there. If we take part of this wire and zoom it, and see the charges there as S_1 has said. Now you're saying they're moving around, where?	E_L
22.S_2	They move there, in their places.	$R_{2.6}$
23.T	Their places …	E_L
24.S_2	No, they're there. It, it – the wire, and once we close it they'll continue their movement. Maybe they were – but when opened – once we close it the movement will keep on …	$R_{2.7}$
34.T	…So directionally, they move in a directed way.	E_L
35.S_2	No – I don't know how. Maybe randomly… And after we close the circuit they will move around – before they didn't move around.	$R_{2.12}$

Students' responses differed also in their quality. Some reflected low cognitive processes while others demonstrated a high level. While presenting such views, some of the students expressed themselves strongly while others were hesitant. In the following two excerpts, two students express their views about the source of charges while describing how the electric current moves in the circuit and reaches the bulb:

9.T	…So these charges that are moving in the wire might finish one day.	E_L
10.S_5	Yeah, they finish.	$R_{5.5}$
11.T	They finish. So, if I brought this wire, Could it end from charges one day?	E_L
12.S_5	Miss, the wire doesn't have charges. It's a conductor for the movement.	$R_{5.6}$
13.T	It doesn't have charges. It's just a conductor for charges. So, where do the charges come from?	E_L
14.S_5	Aren't they coming from the battery!	$R_{5.7}$

Here, S_5 seems very convinced with her view regarding the movement of the charges in general and about the battery as a source of charges in particular. Her confidence appears more obviously in her firm response in turn 12 that the wire does not have charges and in her wondering tone in turn 14 that reflects her belief that the battery as a source of charges is something unquestionable. In contrast, S_6 in the second excerpt talks hesitantly about a view that is scientifically correct and reflects high cognitive thinking:

…S_5	Aren't they coming from the battery!	$R_{5.7}$
…T 13.T	So this battery has charges that feed the wire. And these charges might one day end up. So, this is S_5's opinion… You're disapproving her?	— I
14.S_6	Yes. The battery here gives kinetic energy for the charges to move and maybe the battery.	$R_{6.2}$
15.T	The battery gives the charges a kinetic energy that helps them to pass through. From where these charges are coming basically that it helps them to pass through?	E_L
16.S_6	– (Silence) From the wire.	$R_{6.3}$
17.T	Come from the wire. What do you think? She is telling us that the charges are coming from the wire? What do you think? ()	E_L I
18.S_6	I mean, what I know is that the battery gives kinetic energy.	$R_{6.4}$

S_6, in this excerpt, seems not as sure as S_5 was, and does not present her ideas as strongly. Her hesitation appears obviously in the silence in turn 16, and in her uncertain way of expressing her view saying in turn 18: "I mean, what I know is that…".

The persistence of the elaborative voice of the teacher. The elaborative voice can be heard in both authoritative and dialogic classes of talk. Nevertheless, dialogic talk, in the examples of this stage, illustrates a persistence of the elaborative voice of the teacher through continuous questioning of the student's responses. It is interesting that the quantitative representation of the dialogic examples analysed by the framework manifest a dominance of the elaborative follow-up (E_L) over the evaluative one (E_v) that has disappeared completely (Table 4).

Table 4. Comparison between E_v and E_L in I/D excerpts

I/D Excerpt	*Follow-up*		*I/D Excerpt*	*Follow-up*	
	E_v	E_L		E_v	E_L
Les.2, Part 1	0	2	Les.3, Ex.2, Part 2	0	4
Les.2, Part 3	0	3	Les.3, Ex.3	0	5
Les.2, Part 4	0	13	Les.4, Part 1	0	6
Les.3, Ex.1	0	6	Les.4, Part 2	0	10
Les.3, Ex.2, Part 1	0	8	Les.4, Part 3	0	…

The follow-up move was characterized as elaborative since it is meant to extend the students' answers. Many elaborative moves demonstrated by the teacher in the examples of this stage took different forms of eliciting, diagnosing and prompting the students' responses. She kept on questioning students' answers, asking them to explain more about their ideas and encouraging them to criticise or evaluate their peers' views. She also used the elaborative move to challenge the students' unfamiliar ideas. After identifying them, the teacher, in many examples, was negotiating these ideas with the students who presented them by trying to raise a doubt about their possibility in front of the whole class. She was doing this through her persistent and detailed questions accompanied by a wondering doubting tone. The following excerpt demonstrates the teacher's utilisation of the elaborative questions to explore and challenge the students' ideas:

This talk was exchanged after the students performed a practical activity related to a simple electric circuit with short wires, and observed the instant glow of the

T	OK, if I brought now instead of the short wires I've used, I use very loooong wires, will the bulb light instantly? Or after a short period of time? Or after a long period? What do you think?	I
S_3	Instantly.	$R_{3.1}$
T	Instantly. So, if I used wires, their length, for example, equals the length of the class, will it light instantly? How many of you agree with S_3? S_4, you've said you disagree with her, why?	E_L I
S_4	Maybe because the charges need time till they arrive.	$R_{4.1}$
T	Maybe because the charges take time to reach the bulb. Because charges are coming from where to take time?	E_L
S_4	Come from the battery.	$R_{4.2}$
T	Come from the battery, and of course the journey will be longer. This is S_4's point of view. S_3, you're saying instantly, why? Don't they take time to move from the battery to the bulb?	C_0 E_L
S_3	No.	$R_{3.2}$
T	Why, are they fast like the flash-lighting?	E_L
S_3	Yes.	$R_{3.3}$
T	So, the bulb lights instantly because of their high speed? This is the reason?. S_5	E_L …I
S_5	… For example, if we notice the ones at home. When we turn them off, they go out immediately.	…R_5
T T	… So, you're saying this happens' cos charges are fast … S_5 is saying because of the speed of the charges, and S_6 is saying because of the power of the battery, OK? Let's hold this question to answer tomorrow, but think about it. Now, let's do the activity with the long wires. All of you, pay attention …	C_0 C_0

bulb. Here, the teacher chose to challenge the view of students regarding the instant lightness confirmed by the first activity by changing one variable; the length of the wires. Before conducting the activity under the new condition, she probed the students' predictions about it. She listened to four students; S_3, S_4, S_5 and S_6 before closing the talk to perform the activity.

The share of control over the talk between the teacher and students. Classifying talk as Dialogic is based on the absence of the evaluative follow-up of the teacher and the openness of the talk to students' personal views. This openness *per se* illustrates the contribution of students in guiding the talk, which includes verbal and intellectual participation. It is quite easy to see the students' role in keeping on the discussion in all Dialogic examples, as proved by all the excerpts presented in this section. Nonetheless, let's use one of the many Dialogic excerpts to direct the attention to how the students were playing the 'big' role:

…T	So …It starts from the battery till they reach the bulb?	E_L
8.S_3	Yeah. Then the positive goes – then meet together – the bulb needs positive and negative charges.	$R_{3.2}$
9.T	So this bulb needs positive and negative. OK, come and show us this movement in the electric circuit.	C_0 I
10.S_3	(Explains by talking and drawing that the negative charges will come out of the negative pole of the battery and pass through the wires, and positive charges start from the positive pole and pass through the wires too, and when the two meet together in the bulb, it lights. She, however, mentions that positive charges do not cause the bulb to light up.)	$R_{3.3}$
11.T	S_3 is saying that the current. So, the path of the current as she said … Starts…The positive charges start from the positive pole. OK, how do they go to the bulb?	C_0 E_L
12.S_3	They pass like this.	$R_{3.4}$
13.T	So they also complete their round?	E_L
14.S_3	Yes.	$R_{3.5}$
15.T	Starts from the positive pole till they reach the bulb and completes its round, but don't they light up the bulb?	C_0 E_L
16.S_3	No.	$R_{3.6}$
17.T	Don't they help in lighting the bulb?	E_L
18.S_3	No, unless the negative and positive meet in the bulb.	$R_{3.7}$
19.T	So the bulb lights by the meeting of the charges…. Is there anyone has a disapproving opinion in describing the path of the current?	C_0 I
20.S_4	I don't disagree totally. I mean, I disagree with her when saying that it completes its round. It doesn't complete its round. It changes, I mean the lighting – still it has a kinetic energy. Then, it starts to lose its kinetic energy to light and heat, so the bulb lights because – I mean the energy has been lost because of the resistance.	$R_{4.1}$
21.T	You've moved to the energy, you're saying that these charges… and when it reaches the bulb it's to be transformed into what?	E_L

In this example, S_3 explainsher view regarding the path of the current. The teacher carries on the talk with her through many turns before directing the talk to another student, S_4 (…E_L-$R_{3.2}$-C_0-I-$R_{3.3}$-C_0-E_L-$R_{3.4}$-E_L-$R_{3.5}$-C_0-E_L-$R_{3.6}$-E_L-$R_{3.7}$-C_0). She kept seeking more clarification from S_3, and asked her to draw the route of charges (turn 9). She reviewed then her contribution by putting it into two points and writing them on the board (turn 11) before further following her ideas through the turns (11–19). It is not before she thinks that she could reveal the S_3 thinking about the current route, that the teacher shifts the talk to the class asking for another opinion in turn 19. In turn 20, S_4 presents a more complex view of high cognitive thinking about the energy within the whole system of the electric circuit's work. The talk continues to bring out S_4's view (I-$R_{4.1}$-E_L…).

Both the teacher and students were sustaining this talk, with the verbal control going back and forth between them (Students: turns 10 & 20, Teacher: turns 11 & 19). It can also be seen that although the teacher had the power in directing the questions, the talk was guided by the students' thoughts and opinions without any reference to 'a correct scientific one'. This means that the students were like the source of knowledge here, while the teacher was receiving and making sure she 'gets it all'. The talk was not moving towards a certain scientific account approved by the teacher, but towards the students' views, which allowed them in turn an intellectual control over the talk.

Similar to the authoritative talk, the analysed examples of dialogic talk showed differences in the four characteristics explained above. In some, all of the general characteristics seem to feature in the talk while in others some of them disappear completely or look less evident. This also resulted in viewing the dialogic talk along three general levels of high, mid and low.

REFLECTION AND IMPLICATIONS

This chapter described the quality of interaction in Omani science classes in relation to how authoritative or dialogic they were, using data from one case that was observed before and after a training intervention. The results demonstrated a noticeable change between the two stages, with more and varied examples of dialogic talk in the second stage after the intervention that aimed to encourage the teachers to allow more space for the students' voice. It was not intended that Al-Mahrouqi's (2010) study would evaluate the principles of the Basic Education system in the observed science classes. Nonetheless, these principles initiated the interest to look into the nature of the discursive interaction in these classes, and the potential to promote its quality. The chapter focussed on describing the characteristics that featured each type of talk, as demonstrated by the practice of one science teacher in the Omani context. The data from the two stages was very rich, and contributed eventually to the development of the methodological tool of the CA. The deep and detailed analysis that this data went through, also contributed to raising a number of issues and lines of argument that have implications for research and teacher professional development.

Effective use of talk in the practice of teaching and learning is central to the teacher's professionalism. However, changing the quality of talk in the classroom necessitates changes in professional practice which cannot be reduced to a one-shot training session. It is not easy as it requires effective training, adequate time and resources, support and cultural change, among other requirements (Keogh & Naylor, 2007). I do not claim that Al-Mahrouqi's (2010) study has made a sustained change in the professional practice of the participating teachers, yet it has met its planned purposes, so that its experience might be of use for studies working in a similar research context. Nevertheless, what the study has followed in terms of methodological approaches to analysing data, and what it has produced in describing the nature of talk and its quality through different styles of presentation, all provide valuable inputs for a sustained programme of teacher training to promote dialogic talk and dialogic teaching more generally.

The detailing of each authoritative and dialogic type offers a wide range of information that can be incorporated into such a programme. Such information is expected to provide a clear description of what constitutes authoritative and dialogic interaction, which might allow the teachers to discuss their practices in view of it. In this context of teacher training programme on dialogic teaching, two methodological strategies that were used by this study are relatively important:

- The first relates to providing quantitative and graphical representations of the teaching interaction. One can see how the numbers and pie-charts, as partly offered in this chapter, afford an 'at a glance' view. They summarise the whole teaching by giving the percentages of each of the practised classes of talk; and differentiate between them by quantifying the different types of follow-ups, and the quality of questions and responses. Such results that this or similar studies can provide need to be integrated into teacher training, but most importantly it might be useful for the training programme itself to make use of these strategies in its design to support and evaluate the practice of the trainee teachers.
- The second strategy relates to using excerpts of talk to exemplify and clarify the presented results. Sometimes, it involved taking a whole chunk of CT and at other times taking single utterances from different incidents of talk, as seen in this chapter. Regardless of different ways of presentation, these examples were the backbone of the analysis, which gave it credibility and validity. Likewise, the strategy can be employed to stimulate and support discussions during a training programme.

What is more, for an intense programme of teacher training, the multilevel 'authoritative-dialogic' model developed from the CA can be employed to characterize the progression of the teachers. Trainee teachers can be observed prior to and after certain stages of the training, and their progress can be followed. Using the figure of authoritative and dialogic levels to advise the teachers about where they were and how far their practice has developed can be a powerful tool to promote dialogic practice. Telling them that they do not have to jump from authoritative to dialogic but rather that they can progress in their dialogic practice, that authoritative talk of lower levels is worthwhile, that dialogic talk of lower levels is not enough; all such insights can engage and motivate the teachers because they convey the message that different CT practices are needed and that the development of these practices is an ongoing and sustained process that needs time and experience, but one which they can be guided through. This can in turn empower the teachers to use the different levels of the two types of talk appropriately and effectively.

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5. SCIENCE EDUCATION REFORM AND RELATED CULTURAL ISSUES IN BAHRAIN

A Historical Move

ABSTRACT

This chapter aims to present a picture of the ongoing science education reform in Bahrain, which goes back to early times in the history of the country. Document analysis, interviews and textbook review were used. Statistical data were obtained from valid and reliable sources. Bahrain gave special concern to literacy at early concern and continual reform of education as far back as the beginning of the twentieth century.

The chapter shows that curriculum development and reform in general and that of science education in particular were of focal interest to curriculum specialists in Bahrain in order to keep up with the worldwide trend, especially the Western world. This continual reform meets the need for frequent science curricular changes for keeping up to date with recent discoveries in science and technology. Considering the interaction between science, technology and society, which was the trend in the 1980s, was adopted in the current Bahraini science curricula for all schooling stages. Recent curricula in this field have been adopted by the ministries of education in Saudi Arabia and Bahrain in an Arabic translated and modified version of the McGraw-Hill Companies' US series. The Obeikan Investment Group was chosen for printing and publishing the modified versions of the textbooks for each of these two countries, according to a three-year plan that ended in 2012. Instructional methods were also modified accordingly. The dry labs (computer simulated experimentation) that accompany the new trend towards virtual learning were introduced in science teaching in Bahrain, principally at the secondary school stage.

INTRODUCTION

Before discussing the current reform of science education in Bahrain, it is important to give the reader some brief facts about the country's location, society, culture, economy, and education. Such facts would be helpful for a clear understanding of the ongoing reform of education in general and of science education in particular. Official documents, interviews with experienced former science teachers and educational leaders, and textbook analysis were the source of the forthcoming information.

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 97–120.

BAHRAIN: LOCATION AND SOCIETY

Bahrain is located in the middle of the Arabian Gulf and comprises an archipelago of 32 islands. It is 23 km away from the eastern coast of Saudi Arabia and since 1986 these two countries have been linked by a 23 km-long causeway. It is a relatively small country in both area (711 square km) and population (1,234,571). Only 46.04% of its population are native citizens, the other 53.96% are foreigners (Central Informatics Organization, 2012). It ranks the eighth among the highest population density (1736 persons per square kilometer) in the world (Infoplease, 2014).

The official language is Arabic. English is very widely spoken and is the principal language of commerce. Islam is the official religion of the country; other religions such as Christianity and Judaism also have some followers, but with small percentages.

SOCIAL ENVIRONMENT AND CULTURE

The social environment in Bahrain is highly attractive to foreign capital. Bahraini citizens are well educated; the illiteracy rate in the country is almost negligible: 1.4% for males, 4% for females and 2.7% for both combined (Central Information Organization, 2007). Bahraini people, as Al-Khalili (2008) indicated, are generally polite, friendly and respectful to others, especially those of different cultures. Foreigners find it highly encouraging to reside with their families in Bahrain, since they can find all kinds of facilities they like. In addition, Bahrainis highly value education. The government grants a scholarship for every high school graduate, either within the country or abroad, whose Grade Point Average GPA at secondary school exceeds a mark of 90%. It also grants an opportunity for those whose GPA exceeds 70% to be accepted at the only national university in the country (University of Bahrain). Bahraini citizens are very enthusiastic when it comes to enrolling in on-the-job training programs and workshops that are offered by different institutes such as the University of Bahrain, which established a centre for this purpose

The overall cost of living in Bahrain is much lower than in most European countries, and utilities such as electricity, water, and gas are subsidized by the government (Economic Development Board (EDB), 2012b). The government does not force exchange control on the movement of money, nor does it tax personal income, wealth, capital gains, and death duty or inheritance.

OVERVIEW OF THE BAHRAIN ECONOMY

It is a matter of fact that the economy affects all aspects of life including education. Thus giving some brief background information becomes relevant for presenting a clear picture of educational development in the country.

Bahrain, as stated by Economic Development Board (2008), is one of the most diversified economies in the Arabian Gulf. It has highly developed communication and transport facilitiesthat makes it home to numerous multinational firms with business in the Gulf. As part of its diversification plans Bahrain implemented a Free Trade Agreement (FTA) with the US in August 2006, the first FTA between the US and a Gulf state. Bahrain's economy, however, continues to depend heavily on oil. Petroleum production and refining account for more than 60% of Bahrain's export receipts, 70% of government revenues, and 11% of GDP (exclusive of allied industries). Other major economic activities are the production of aluminum – Bahrain’s second biggest export after oil – finance, and construction. Bahrain competes with Malaysia as a worldwide centre for, banking according to Islamic religion which is usually termed as Islamic banking. It continues to seek new natural gas supplies in order to support its expanding petrochemical and aluminum industries.

In 2011, Bahrain experienced economic setbacks as a result of domestic unrest. Contrary to the Economic Vision 2030 for Bahrain (EDB, 2008), that presents the future path for the development of the economy and society, Bahrain’s reputation as a financial hub of the Gulf was damaged, and the country is fighting the risk of losing financial institutions to other regional centres such as Dubai or Doha (Countries of the World, 2013). Economic policies aimed at restoring confidence in Bahrain's economy, such as the suspension of an expatriate labour tax, make Bahrain's foremost long-term economic challenges – youth unemployment and the growth of government debt – more difficult to address.

The EDB (2012a) indicated that Bahrain has the fastest growing economy in the Arab world. It also has the freest economy in the Middle East/North Africa region, and its economic freedom score is well above the world average according to the 2014 Index of Economic Freedom (2014) published by the Heritage Foundation, Wall Street Journal. This index revealed that Bahrain’s economic freedom score is 75.1, making its economy the 13th freest overall in the world in 2014. Thus, it became home to members of multinational firms with business in the Arabian Gulf. Consequently, majoring in business fields became the most favored selection to high school graduates and the College of Business became the biggest college at the University of Bahrain. Such an environment requires that the educational system has to be modified for meeting the needs of this environment.

THE EDUCATION SYSTEM IN BAHRAIN

The education system in the kingdom of Bahrain is wide enough for meeting the needs of a competitive economy (EDB, 2012). Numerous international educational institutions and schools have established links to Bahrain. There is a choice of Bahraini, British, American and Lebanese systems in private schools. Although the presentation in this chapter is limited only to the development of science education curricula adopted in public schools, some glimpse can be given to private schools for the completion of the development of schooling and education in the Bahraini educational system. Following is a brief historical presentation on educational development in Bahrain.

EDUCATION IN BAHRAIN PRIOR TO THE TWENTIETH CENTURY

Teaching in Bahrain goes back to the roots of its history, which yield a rich history of cultural development. At the end of the nineteenth century and the beginning of the twentieth century, teaching was performed as circles in mosques or as regular meetings of private councils of scientists in their homes. These were termed as Islamic schools since the holy Qu'ran and Hadith of prophet Mohammad were the main subjects of teaching (Mahadeen, 2010). Literature saloons (as they were named then) were also prevalent. Every scientist, mullah, litterateur or poet would assume a synod for himself where interested people would gather and learn from him. Alnwaydri (1992) documented the resumes of scholars of these synods. Such an environment indicates that Bahraini people were literates in contrast to the prevalent illiteracy in Arab lands governed by the Ottoman Empire.

Teaching was undisciplined[1] or random in what used to be called katateebs tied mainly to mosques rather than with government institutions. Teaching in these katateebs concentrated mainly on the three basics: reading, writing and arithmetic. The teacher, usually named as a mutawa or mullah, was the person who decided what would be taught to each group of children. No systematic curricula existed; only the mutawa's decision was the basis of teaching, and this was the curriculum. Such teaching was prevalent in Bahrain during the eighteenth, nineteenth and the early years of the twentieth century (Mahdeen, 2010). Some of these katateebs devoted time to teaching children skills needed for Bahraini society like fishing, and diving for pearls. Some accountancy and marketing were also taught; skills needed for trading. Children had to pay the mutawa at the end of the week, which was on Thursdays.

EDUCATION IN BAHRAIN FROM THE BEGINNING OF THE TWENTIETH CENTURY UNTIL INDEPENDENCE (16 DECEMBER 1971)

Disciplined teaching in Bahrain began with the establishment of regular private schools. In 1889, Ahmad Almahza established a religious school in Manama. In 1892, the American Mission established the first regular elementary school. Samuel Zwemer was managing this school and at the same time teaching at it. It was a mixed school without segregation of boys and girls. The three Rs (reading, writing, and arithmetic) alongside the Christian religion were emphasized in this school. No textbooks were used. Science was not taught, only Zwemer himself, being a dentist, gave some lessons focusing on personal health. In 1900 this mission established the first school for girls; there were 50 girls in this school (Mahadeen, 2010).

Schools were established in 1910 by the Alajam (a non-Arab group of Iranian origin) and named Aletihad schools, which were completely supported by Iran. The Ali bin Ibrahim Alzayani school was established at Moharraq in 1912. The Al-Hydaya AlKhaleefia school was first established in 1917, temporarily on the campus of Alzayani school. The Holy Heart school was established in 1953 (Mahadeen, 2010). All of these schools were just elementary schools (grades 1–6). The school day was divided into two sessions, morning and afternoon, with a lunch break of an hour to enable children to have lunch at home.

The katateeb remained until the 1940s, alongside the regular schools. Some Bahraini citizens who had been abroad for trading in India or in Europe would teach in these schools. Generally speaking, teaching in Bahrain until 1919 was religious, with a concentration on recitation of the Holy Qu'ran. Mahadeen (2010, pp. 12–13) presents documents that give credit to Alsayed Ali Ibrahim Alrastaquias, a pioneer in establishing a school that served societal needs alongside the recitation of the Holy Qu'ran. Diving for pearls and trading in them was one of the major sources of income. Thus handwriting skills, calculation, creating contracts, recording debt, and contacting traders were subjects taught at his school. Mahadeen also records that Ali Bin Ibrahim Alzayani built a school in 1912 on his own account which hosted the first disciplined school (Al-Hydaya Al-Khaleefyah). In 1919 when pearl traders formulated a committee for establishing a discipline for education in Bahrain they opened doors for donations to support established schools, which became supervised by this committee. Sheikh Abdullah Bin Isa who was a son of prince Isa Bin Ali headed this committee and gave it the necessary support from his father who was the leader of Bahrain at that time. The committee was able to complete the permanent building of the Al-Hydaya Al-Khaleefyah School in 1926.

DISCIPLINED EDUCATION IN BAHRAIN

Mahadeen (2010) indicated that in 1926, Charles Belgrave was appointed by the UK as an advisor to the Bahraini leader. Belgrave began to interfere in the work of the committee of education and a conflict occurred with them. By this time, Alajamhad had established two private schools, which were the Aljaafarya School in Manama and the Almobrakya School in Alkhamees. Teachers at these schools were expatriates from Iraq.

In 1930, Belgrave forced the committee of education to become affiliated to the government, which began to pay salaries for teachers. Thus, 1930 could be considered the starting date of disciplined education in Bahrain (Ministry of Media, 2009). No specific curricula existed in the schools affiliated to the government. Teachers decided what textbook to teach from, based on their nationalities: Egyptians adopted Egyptian texts, Syrians adopted Syrian texts, Iraqis adopted Iraqi texts, and so forth. Science as a school subject began to be included in what was taught, along with religion, Arabic and history.

In 1928 the government of Bahrain sent eight students to complete their learning at the American University of Beirut, who came back after graduation to lead the movement of improving education in the country. In the same year, the disciplined teaching for girls in Bahrain was initiated. It is worth noting that the majority of children who went to school at that time came from wealthy families.

In 1936 the government appointed a general director for education responsible for all schools. Frouque Adham, a Lebanese, was the first to be assigned to this job. Both of the Aljafarya and Cunia committees were unified under the leadership of this governmental directorate.

In 1939 Adrian Smith took over from Adham. He divided schooling into two stages: introductory and elementary. In 1940 he established the Almanama College, which accepts graduates from elementary school to continue learning for two years. Those who finished studying at this college were assigned as teachers at elementary schools in Bahrain.

In 1944 a mission of Egyptian teachers joined teaching staff in Bahrain. These teachers brought their homeland textbooks with them. A vast improvement was made to the teaching. Varieties of school subjects were introduced, these included religion, Arabic language, mathematics, science, history. Each of these subjects has its own textbook and a specified teacher.

In 1946 Ahmad Alumarn was appointed as a director of education. He remained in position until 1971 and then became the first official Minister of Education in Bahrain with its independence on16 December1971. Many improvements happened during his leadership of education. More schools were established in the villages of the country, subject matter supervisors were appointed, teachers other than Egyptians were hired, unification of higher administration of education of boys and girls was established.

In 1960 the secondary stage was introduced to the schooling system, consisting of four years after the primary stage. In 1963 the intermediate stage was introduced in the schooling system as a two year stage after the primary stage, and the secondary stage was reduced to three years. Thus, the schooling system became an eleven-year system.

In 1972 one more year was added to the intermediate stage. Thus, the school system became twelve years long. After the completion of the intermediate stage, students are directed to four types of specialization in the secondary school: general (scientific, or literary), commercial, industrial, or applied (textiles or advertising).

Besides this general schooling system, Bahrain offers a specialized track for children whose parents select religious education, from first grade through intermediate to secondary. Thus schooling according to this public system is divided into three stages: elementary (grades 1–6), preparatory (grades 7–9), and secondary (grades 10–12). The elementary stage is divided into two cycles: first cycle (grades 1–3), and second cycle (grades 3–6). This system (see Table 1) remained as such until today, with some slight modifications.

Table 1. The educational ladder in Bahrain

Grade	*Age*			
12	17	*Secondary Education:*		*Religious Education* Primary, Intermediate and Secondary
11	16	Commercial	Industrial	
10	15	General: *Sciences/Arts*	Applied: *Textile/Advertising*	
9	14			
8	13	*Basic Education:* Third Cycle (Intermediate)		
7	12			
6	11			
5	10	*Basic Education:* Second Cycle (Primary)		
4	9			
3	8			
2	7	*Basic Education:* First Cycle (Primary)		
1	6			

Source: Ministry of Education (2004)

EDUCATION IN BAHRAIN FROM INDEPENDENCE UNTIL TODAY

After the independence of Bahrain in 1971, Shaikh Abdelazeez Al-Khaleefa was appointed as a minister of education who began a major move for the improvement of education. Among these improvements, the first law of education in Bahrain was legally formulated. Girls' schools were established all over the country, based on his strong belief that women must have an equal chance as men to learn. National books that fit the Bahraini societal needs were authored for all grades – no more dependence on Egyptian textbooks.

Improvement in all aspects of education continued drastically. It is out of the scope of this chapter to cover the details of this move. It only needs to be mentioned that in 1990 the credit hours system was introduced to all types of specialization at the secondary stage. According to this system school subjects were given different weights in a student's grade point average based on the number of weekly hours of contact, which is the system followed at university. This system faced many obstacles and problems, which forced the Ministry to modify it. Apart from this major change in the secondary stage the schooling system has remained much the same up until today.

THE MODERN DEVELOPMENT OF EDUCATION IN BAHRAIN

As indicated previously, educational reform in the Kingdom of Bahrain has passed through different stages of development. The modern development stage that spanned from the 1980s until now centred on high quality education through a mechanism for development projects that boosts the quality of services on one hand and the quality of the educational process on the other, as per the requirements of each development plan (Ministry of Education, 2012).

Recent global and technological changes have transformed education in Bahrain at all levels. These changes are creating an increasing demand for knowledgeable, critical and creative thinkers who are proficient across core learning areas such as science, technology and Society. The impetus for these changes is the recognition that successful 21st century productivity requires that students are able to think critically and understand how to effectively use information in all of its forms (Ryba & Selby, 2009).

Bahrain's Economic Vision 2030 presents the future path for the development of the economy and society. The Ministry of Education has put this Vision 2030 into practice through the establishment of many new educational initiatives, among which is the establishment of King Hamad's 'Schools of the Future' project. Improving the quality of education across all levels in every school is another project. A significant shift is from traditional instruction to student-centred approaches in which the teacher becomes a 'knowledge management specialist' who encourages more active and self-directed learning and creates effective learning environments for all of his students. E-Learning, dry laboratories and the blended approach of science instruction have all proved to be very important in the development of student-centred approaches and as a means of actively engaging students in the process of developing 21st century.

The Ministry of Education in Bahrain has continued to work on improving its educational system in all dimensions, which has yielded social, economical and political development of the country from early times. Bahrain was a leading country in the region that legislated decentralization in its educational system from the 1980s (Ministry of Education, 2001).

Educational research was of focal concern in Bahrain. A special centre was established for connecting research with development in 1980. Many grants were given to researchers for carrying out studies according to well-organized plans.

The Ministry of Education initiated a yearly scientific conference in 1985. Twenty-six sessions of this conference have been organized up until now, each of which was devoted to a specific theme. Concerned teachers, practitioners, and policymakers were called to participate in these conferences. Experts were asked to present research articles, new discoveries, trends, and theoretical perceptions around the set theme of each conference. Workshops for teachers and principals were arranged to accompany each of the conferences. Performance at all levels was given special emphasis in evaluating all elements of the educational system, including students, teachers, principals, assistant principals and schools as an overall unit. With the new trend of quality assurance, schools were obliged to undergo an assessment process for quality.

Teachers were of focal concern of the Ministry of Education. An Educational Diploma was set as a compulsory condition for joining the teaching profession, alongside the bachelor degree. But these qualifications were not enough for an assurance of good quality of the teaching and learning process, so to keep teachers up to date, a special administrative department at the Ministry of Education was established and charged with organizing ongoing training workshops. Among the training workshops implemented for teachers are the following: enhancing teacher efficacy in his/her field of specialization, basic computer skills, International Computer Driving License (ICDL), and teaching learning strategies, to name but a few.

A special administrative supervision unit was established in 2005 for improving outputs of the teaching and learning process, represented by students (Zayani, 2007).

The idea of having a head teacher was first introduced in 1993 in the secondary schools. Based on experience and qualification, a head teacher was selected as leader to each group of subject matter teachers. It was expected of him/her to take the role of supervising his/her colleagues in a friendly atmosphere, helping them to solve problems, sharing successful experiences, unifying tests and examinations, and arranging peer visits as a way of giving advice and reciprocal benefits. The head teacher idea was generalized to the intermediate stage in 2001 and the primary stage in its two cycles in 2011.

The Ministry of Education (2009) adopted a set of 14 initiatives for development, among which were the following: Developing the Role of School Administration, Professional Development of Teachers, Teaching for Learning, Developing School Curricula (especially science and mathematics), the National Initiative for Teaching and Training, and Developing School Performance through a Set of Five Projects. It is beyond the scope of this chapter to elaborate on all these initiatives, however, reference will be made briefly at a suitable context.

King Hamad's Schools of the Future Project

Introducing technology in Bahraini public schools started in 1985 when computing was introduced as a special subject in high schools. It was either compulsory or as an elective subject in 46 out of 113 schools.

In 2001, the Ministry of Education (2005) formulated a vision and strategy on applying Information and Communication Technology (ICT) at all schooling stages. This project, usually indentified as King Hamad's Schools of the Future project, was a fundamental turning point from the traditional teaching-learning process to a future process based on using technology, introducing e-learning with all of its advantages. The overall ratio of students to computers at all public schools is 19:1, broken down to 7 at secondary level, 34 at the intermediate level and 36 at the primary level. All schools were connected to the internet by three to 12 computers alongside printers and the necessary network that connects the equipment in the computer lab. The number of computer labs varies according to the type of school. It is 7 to 11 labs in commercial schools, 6 to 7 in industrial schools and 2 to 3 in academic schools.

The project started with trials in 11 secondary schools: five for boys and six for girls. Schools were provided with the necessary equipment and projection screens. The schools were linked through a network developed in cooperation with Batelco (the major telecommunication company in Bahrain). Textbooks were transformed into interactive digital e-books and teachers were trained to teach at this kind of school. This project, after being piloted, was extended to all secondary schools in Bahrain.

Concerns Regarding the Quality of Education in Bahrain's Schools

Bahrain cares about the quality of education at every level, including schools and universities. For this purpose, the Quality Assurance Authority for Education & Training (QAAET) was established as an independent national authority attached to the cabinet and set up under Royal Decree No. 32 of 2008, amended by the Royal Decree No. 6 of 2009. It was established for raising standards in education and training (QAAET, 2012). The Schools Review Unit (SRU) is a section of QAAET that is responsible for reviewing, monitoring and reporting on the quality of the provision of education in schools. It identifies the strengths in provision and areas for improvement. The SRU also establishes success measures and spreads best practice.

Review involves monitoring standards and evaluating the quality of provision against a clear set of indicators. The reviews are independent, objective and transparent. They provide important information for schools about their strengths and areas for improvement in order to raise standards. Review grades are awarded according a four-point scale (see Table 2).

Table 2. Grading scale of reviewer's report[2]

Grade Description	*Interpretation*
Outstanding (1)	Outcomes or provisions are at least good in all areas and outstanding in the majority.
Good (2)	Outcomes or provisions are at least satisfactory in all areas and good in the majority.
Satisfactory (3)	A basic level of adequacy. There are no major weaknesses, or the majority of areas are satisfactory. Some areas may be good.
Inadequate (4)	There are major weaknesses, or the majority of areas are inadequate.

Source: QAAET Review Reports (2012)

An Executive Director heads the Schools Review Unit (SRU) and the national team consists of competent review directors and reviewers who are very experienced in the field of education and include several school principals. They have been trained by the SRU's international partner Nord Anglia Education. SRU is independent of the Ministry of Education (MoE), and the MoE plays no part in the review. It does, however, support schools before and after the review, and will therefore receive copies of all reports after the Board of the QAAET and the Cabinet approves them.

In view of its commitment to credibility and transparency, the Authority publishes e-versions of the reports on the quality of educational and vocational institutions (QAAET Review Reports, 2012). These reports present the outcomes of the reviews of the institutions that have been evaluated. They are based on the most important findings of the review units' visits to schools, vocational providers and higher education institutions. The reports highlight institutions' strengths and areas for improvement, together with recommendations for development. This is in line with the QAAET's remit of independent evaluation of educational and training establishments as part of Bahrain's education reform programme and Economic Vision 2030.

The main objective of the SRU is to help schools to improve, by providing an expert external and impartial check on the following:

- Standards and achievement
- The personal development of students
- The quality of provision in:
  - Teaching and learning
  - Curriculum enhancement
  - Support and guidance
- Leadership and management

The review takes place over a three-day period when a team from the SRU visits the school. During the review there are lesson observations; an analysis of documents; a scrutiny of students' work; and interviews with senior staff, students and parents. At the end of the review, the Principal is given final feedback and judgments.

Following the review a report is produced which highlights the main findings and the judgments. The judgments are based on a scale of 1 (outstanding) to 4 (inadequate). The Principal has an opportunity to comment on the report before it is finalized. Once the report is final, the school must provide a Post-Review Action Plan. The plan should set out clearly how it intends to improve in the areas identified in the report.

The SRU has carried out the first cycle of reviews which started in September 2008; to date, 184 of 204 public schools in Bahrain have been reviewed, of which 41schools were reviewed more than once. Table 3 shows a frequency distribution of the results of the first review according to grades awarded. Table 4 shows a cross tabulation of how ratings changed in the second review.

Table 3. Frequency distribution of the results of the first review according to grades awarded

Grade	*Frequency*	*Percentage*
Excellent (1)	7	3.80%
Good (2)	56	30.43%
Satisfactory (3)	87	47.28%
Inadequate (4)	34	18.47%
Overall	184	100%

It is evident from Table 1 that most schools were rated as satisfactory (47.28%), and only seven schools (3.80%) got a rating of excellent. Less than third (30.43%) got a rating of good, and 34 schools (18.47%) got a rating of inadequate.

If feedback works well and schools benefit from the first evaluation, there should be a shift towards improvement. However, by cross tabulating the ratings of the second review with that of the first reviews (see Table 4), the results were not encouraging. Only three schools (7.32%) improved from good to excellent, and seven (17.07%) improved from satisfactory to good. On the contrary, seven schools (17.07%) drew back from good to satisfactory and seven more (17.07%) drew back from satisfactory to inadequate. Fourteen schools (34.14%) remained as they were.

Table 4. Results of cross tabulation of the first review and second review according to grades awarded

1st Review / *2nd Review*	*Excellent*	*Good*	*Satisfactory*	*Inadequate*	*Overall*
Excellent	1 2.44%	3 7.32%	0	0	4 9.76%
Good	0	1 2.44%	7 17.07%	1 2.44%	9 21.95%
Satisfactory	0	7 17.07%	12 29.26	2 4.88%	21 51.22%
Inadequate	0	0	7 17.07%	0	7 17.07%
Overall	1 2.44%	11 26.83%	26 63.41%	3 7.32%	41 100%

HISTORICAL DEVELOPMENT OF SCIENCE CURRICULA, TEXTBOOKS AND INSTRUCTION IN BAHRAIN

After the above brief general historical presentation of the development of education in Bahrain, focus in the following sections will be on only the science curricula, and how societal needs and conditions were taken into consideration in the associated science textbooks. For clarity, presentation is organized according to the present schooling stages adopted by the country.

Primary School Science Textbooks and Instruction[2]

Mahfoodh (2013) and Bastaki (2012) said that early in the twentieth century, science was not taught as a separate subject at the primary grades. Only a few science topics were taught within the Arabic subject, and they concentrated mainly on personal health. With the rise of disciplined schools, science was introduced as a separate subject. The textbooks used were those brought by expatriate teachers from their home countries without any modification, even the name of the country from which it was brought. Egyptian science textbooks were the ones mainly used in Bahraini schools.

These science textbooks were not based on well-prepared curricula that took societal conditions and the Bahraini environment into consideration. These textbooks concentrated on content, without any concern with the processes of science. Lectures were the traditional method of teaching, and if experiments were performed, the teacher would do them as demonstrations. Thus, the ways of teaching science by discovery or by inquiry that appeared effective in the western world were absent in Bahraini primary schools. The involvement of students in science activities such as performing projects individually or in groups was completely absent. Cooperative learning was also not practised. Individual differences were not taken into consideration. Evaluation was only on content that is limited to knowledge and comprehension to a small degree; which means that tests measured memorization only.

At the beginning of the 1970s national science textbooks began to be authored locally, however no specific curricula were followed, and none of the western trends like science technology society (STS) were followed. Some efforts were made to connect these textbooks with the specialties of the Bahraini environment and the society's needs (Ministry of Education, 1981).

The classroom teacher (a teacher who teaches all school subjects) was introduced in 1982 to the schooling system for the grades at the first primary cycle (grades 1 to 3) as a trial project in some schools. In 1987 it was generalized to all primary schools in the country.

In 1985 the unified science curricula of the Gulf Cooperation Council were adopted in Bahrain, that started with grade one and increased each year by the consecutive grade. Textbooks were prepared according to well-designed curricula that took care of the societal needs of Gulf citizens, being of the same culture. The nature of science was taken into consideration alongside the psychological development of the children at the primary stage. A spiral concept of development was followed in the preparation of textbooks, in which each concept was presented in a well-studied sequence from grade to grade with more depth and wider scope.

The local environment was given special concern in these unified science curricula (Ministry of Education, 1994). Petroleum production and refining, and the sea in connection with sailing, fish and pearl hunting, were included. Technological applications associated with suitable subjects were also included. Such kinds of modification comply with a national trend in the 1980s that focused on the Science Technology Society (STS) (Arab Center For Educational Research in Gulf States, 1990).

An evaluation study of these curricula was carried out in 1996 (Arab Center for Educational Research in Gulf States, 1996b). Some defects were highlighted, among which was that these curricula need the associated textbooks to be refined to eliminate repetition in consecutive grades; more examples from the local environment should be given in suitable subjects; and some subjects should be compressed so as to make the book more suitable to the time allocated to science in the school curricula.

Current Science Curricula of the Primary Stage in Bahrain

The application of the unified science curricula of the GCC remained in Bahrain until 2006 when the Gulf states began to adopt the Arabic translated version of the McGraw- Hill science series that covers the twelve grades of the schooling system. This new series was translated into Arabic in Jordan, and a joint committee from Saudi Arabia and Bahrain worked on modifying it for meeting the specialties of the Gulf culture and environment. A scope and sequence matrix was prepared for coverage of this series to all grades on the schooling ladder from grade 1 to grade 12. The Obeikan Investment Group was chosen for printing and production of all the textbooks and the associated material including the teacher books, student workbooks and software.

The central aim for adopting this series at all of these grades is the achievement of qualitative development in teaching and learning science. Recent trends in science curricula take into consideration the interaction between science, technology, society and mathematics (STSM), societal needs and cultural actualities, environment requirements, and student age. The number of class periods assigned to science in each grade was taken into consideration in the process of building the curriculum, and unit selection was made without any major deflection from the original US version of this series in English, or deviation from its themes. Recent trends in science teaching were also followed. Treatment of misconception was emphasized at the beginning of each class period, according to constructivist theory. To sum up, this science series takes into consideration recent trends in science curricula, textbook preparation, and the teaching and learning process of science at this primary stage.

Bahrain started the application of these curricula at the first three primary grades (1–3) in 2006. The application of this series to the rest of the primary grades was performed according to a three-year plan starting in 2007 and increased by one grade each year; that is, the new curricula were applied to grade 4 in 2007, to grade 5 in 2008, and to grade 6 in 2009. The science textbook for each grade consists of six units divided equally between the first and second semester. Each unit consists of two chapters. In total, the textbook includes twelve chapters for each of the three intermediate grades.

The five phases learning cycle (Figure 1) originally developed by Bybee (1997, p. 176) was adopted in teaching all science topics in each lesson at the primary stage. This learning cycle, as indicated by the Arkon Global Polymer Academy (2013), rests on constructivism as its theoretical foundation. A constructivist perspective assumes students must be actively involved in their learning, and concepts are not transmitted from teacher to student but constructed by the student.

Figure 1. The five phases of the learning cycle according to Bybee (1997)
Source: Arkon Global Polymer Academy (2013).

Following is a brief description of each of the five phases. Focus is given to how evaluation as a phase is integrated with each of the other phases.

Phase 1: Engagement. Engagement is a time when the teacher is on centre stage. The teacher poses the problem, pre-assesses the students, helps students make connections, and informs students about where they are heading.

Evaluation of Engagement: Evaluation's role in engagement revolves around the pre-assessment. Find out what the students already know about the topic at hand. The teacher could ask questions and have the students respond orally and/or in writing.

Phase 2: Exploration. Now the students are at the centre of the action as they collect data to solve the problem. The teacher makes sure the students collect and organize their data in order to solve the problem. The students need to be active. The purpose of exploration is to have students collect data that they can use to solve the problem that was posed.

Evaluation of Exploration: In this portion of the learning cycle the evaluation should primarily focus on process, i.e., on the students' data collection, rather than the product of the students' data collection. Teachers ask themselves questions such as the following:

- How well do the students collect data?
- Are they carrying out the procedures correctly?
- How do they record the data?
- Is it in a logical form or is it haphazard?

Phase 3: Explanation. In this phase of the process, students use the data they have collected to solve the problem and report what they did in order to find out the answer to the problem that was presented. The teacher also introduces new vocabulary, phrases or sentences to label what the students have already worked out.

Evaluation of Explanation: Evaluation here focuses on the process the students are using – how well can students use the information they've collected, plus what they already knew, to come up with new ideas? Using questions, the teacher can assess the students' comprehension of the new vocabulary and new concepts.

Phase 4: Elaboration. The teacher gives students new information that extends what they have been learning in the earlier parts of the learning cycle. At this stage the teacher also poses problems that students solve by applying what they have learned. The problems include both examples and theoretical challenges.

Evaluation of Elaboration: The evaluation that occurs during elaboration is what teachers usually think of as evaluation. Sometimes teachers equate evaluation with 'the test at the end of the chapter'. When teachers have the students do the application problems as part of elaboration, these application problems are 'the test.

The five phases learning cycle originally developed by Bybee (1997) were adopted in teaching all the science topics at the primary stage. Clear directions for implementing this cycle were given with examples in the teacher guide for each grade (Curriculum Administration, 2009a). Following is how these phases were introduced and clarified in the teachers' guides:

Phase 1: Engagement. In this phase, students' interest is piqued and their attention is gained through posing questions, or performing some practical demonstration, or being shown some material, etc. The teacher raises previous knowledge about the topic at hand and here corrects any misconceptions that students might hold.

Phase 2: Exploration. In this phase, the lesson activities are performed in order to get answers to specific questions or discovering a concept or a rule.

Phase 3: Discussion-Explanation. In this phase, the subject is clarified and simplified for students' understanding. Words, pictures, etc. are used in this phase.

Phase 4: Evaluation. In this phase, students' understanding of the topic is assured through asking a set of suggested questions.

Phase 5: Enrichment and Elaboration. In this phase, the science subject is connected with the society, environment and technology.

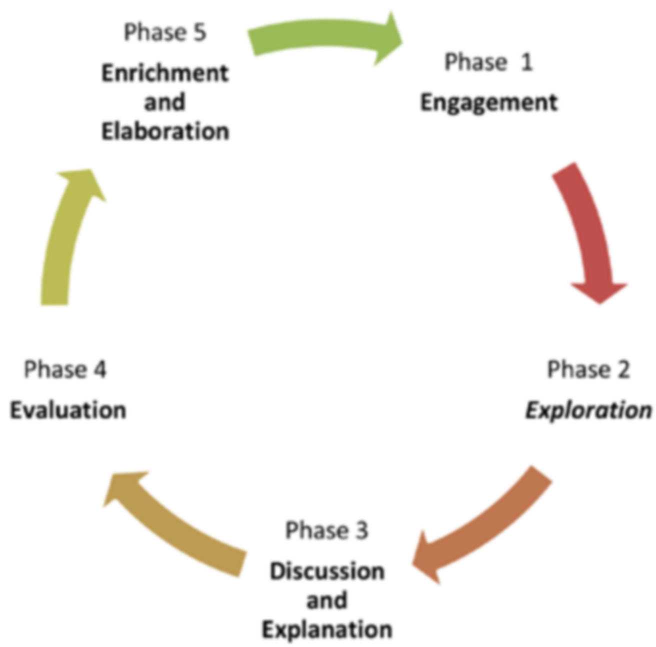

Figure 2. The Five Phase Learning Cycle for teaching science at the primary stage. Source: Curriculum Administration (2009a).

Comparing Figure 1 with Figure 2 we can see that whereas evaluation is connected to each of the other four stages in the original Bybee model, it was used as a final stage in the adopted model. Such a modification raises the question of the effectiveness of this deflection from the original model.

Intermediate School Science Textbooks and Instruction[3]

As indicated previously, the intermediate stage was introduced to schooling in 1963as a two-year stage following the primary stage. In 1972, one more year was added, and so it became a three-year stage. The science textbooks used at the establishment of this stage came from Egypt without any modification. As with the primary stage, these science textbooks were not based on well-prepared curricula that take societal conditions and the Bahraini environment into consideration. These textbooks concentrated on content, with no concern about the processes of science. Lecture was the traditional method of teaching and if experiments were performed, the teacher would do them as demonstrations with light use of materials available in the local environment, such as dissecting fish. Such activities might be the only connection between the science curriculum and the environment. Thus, the teaching of science by discovery or by inquiry that appeared in the western world was absent in Bahraini intermediate schools. Students were not involved in science activities such as performing projects individually or in groups, and cooperative learning was also not practised. Individual differences were not taken into consideration. Evaluation was only on content that is limited to knowledge, and comprehension to a small degree; which means that tests measured memorization only.

In 1995 the Arab Bureau of Education for the Gulf States prepared unified science textbooks for the three intermediate grades. These textbooks gave the attributes of the Gulf environment some attention. Petroleum production and refining, the fishing industry and the desert environment were given some coverage.

An evaluation study of these curricula was carried out in 1996 (Arab Center for Educational Research in Gulf States, 1996a). It indicated that the aims of the curricula were clear and well specified. These curricula also seemed to be helping learners to acquire some functional knowledge connected to daily their living requirements. But learners' interests and needs were poorly treated in these curricula. Arab and Moslem scientists' role in the scientific enterprise was not given enough coverage. Safety in carrying out experiments was ignored. The interaction between science and technology (STS) was not present in these curricula. Many complaints from teachers and parents were raised, especially in the third intermediate grade.

The Ministry of Education in Bahrain responded to these complaints by terminating the application of these unified curricula and replacing them with a local series that was based on a highly organized curriculum. This curriculum (Ministry of Education, 2003) was built on 20 major conceptual schemes that covered four major science fields, as follows: ten from biological sciences, four from physical sciences, and six from earth and space sciences. Scope and sequence was the core of the content organization of this curriculum over the whole basic school stage (primary and intermediate) extending from the first primary grade to the third intermediate grade in a spiral of concept development. As previously noted, this means that each of the major conceptual schemes was covered in each of the nine grades but in a developmental way with the avoidance of tedious repetition. The interaction between science, technology and society was taken into consideration in this curriculum. The Bahrain environment, societal issues, applications of science, and jobs related to each concept were highlighted. Teaching science by discovery and by inquiry at all of its levels (guided to open) was indicated in the accompanying teacher's guide and student workbook at each of the nine grades.

The application of this curriculum started in 2001 at the third intermediate grade. In 2002, the application was extended to the second intermediate grade, and in 2003 to the first intermediate grade.

Current Science Curricula at the Intermediate Stage

As with the primary stage, science curricula for the intermediate stage were changed to the Arabic translated version of the McGraw-Hill science series. Bahrain started the application of these new curricula at the first intermediate grade in the 2007–2008 school year. The consecutive grade (second intermediate) followed in the 2008–2009 school year. Finally, the third intermediate grade used these curricula in 2009–2010.

As indicated previously, a scope and sequence matrix was followed for coverage of this series to the grades in this intermediate stage. Recent trends in science curricula were included to take into consideration the interaction between science, technology, society and mathematics (STSM), societal needs and cultural actualities, environment requirements, and student age. The number of class periods assigned to science in each grade was taken into consideration in the process of building the curriculum and unit selection without any major deflection from the original US version of this series in English, or deviation from its themes. Recent trends in science teaching were also followed. Correction of misconceptions was emphasized at the beginning of each class period, according to constructivist theory. The science textbook for each grade consists of six units divided equally between the first and second semester. Each unit consists of two chapters. In total, the textbook includes twelve chapters for each of the three intermediate grades.

The five-phases learning cycle described above were adopted in teaching all science topics in each lesson at the intermediate stage. Clear directions for implementing this cycle were given, with examples in the teacher guide for each grade.

Secondary School Science Textbooks and Instruction[4]

Nassar (2012) indicated that The secondary stage was introduced to the Bahraini schooling system in 1960. Science taught at this stage was streamed into the traditional major fields: physics, chemistry and biology. The textbooks used at the beginning were from Egypt, without any modification. Consequently, we could conclude that these textbooks did not relate to the societal needs and cultural requirements of Bahrain. By the beginning of the 1980s, local national science textbooks had been prepared. These textbooks remained in use until the adoption of the credit hours system in 1990. New textbooks had to be prepared that fit with this system. The focus in these textbooks was on content; some attention was given to carrying out experiments, but the interaction between science, technology and society was poor. It should be noted that the unified science curricula of the Gulf States was not adopted in Bahrain since it does not fit with its credit hours system.

These local curricula remained in use in Bahrain and Saudi Arabia till 2006 when these two countries began a three-year plan to adopt the Arabic translated version of the McGraw-Hill science series that covers the twelve grades of the schooling system.

Current Science Curricula at the Secondary Stage

As with the intermediate stage, science curricula for the secondary stage were changed to the Arabic translated version of the McGraw-Hill science series. This version was modified to fit the credit hours system followed in Bahrain. In 2007–2008, the first secondary grade was selected to start applying the trial version of this series. In the next year (2008–2009), the consecutive grade was added, and in 2009–2010 the third secondary was included, by which time the textbooks for all of the grades had been changed. The consecutive two years were considered as years of experimentation. Thus 2012 was the year of the official application of this series.

As indicated previously, scope and sequence matrices were followed for coverage of this series for the grades in this secondary stage. Recent trends in science curricula were included, to take into consideration the interaction between science, technology, society and mathematics (STSM), societal needs and cultural actualities, environment requirements, and student age. The number of class periods assigned to science in each grade was taken into consideration in the process of building the curriculum and unit selection without any major deflection from the original US version of this series in English, or deviation from its themes. Recent trends in science teaching were also followed. Correction of misconceptions was emphasized at the beginning of each class period, according to constructivist theory. The science textbook for each grade consists of six units divided equally between the first and second semester. Each unit consists of two chapters. In total, the textbook includes twelve chapters for each of the three secondary grades.

A three-phase learning cycle was adopted in teaching all science topics in each lesson at the secondary stage (Curriculum Administration, 2009b). These phases are as follows:

Phase 1: Focusing. In which students' interest is piqued and their attention is gained for the science lesson through some suggested activities. The teacher should raise previous knowledge about the topic in hand and any misconceptions that students might hold must be corrected at the beginning of the lesson.

Phase 2: Teaching. Suggested methods for teaching each lesson are given in the teacher's guide.

Phase 3: Evaluating. Suggested methods for evaluating students are given at the end of each lesson in the teacher's guide.

Clear directions for implementing this cycle were given, with examples in the teacher's guide for each grade. Moreover, schools were provided with enough computer facilities and software to enable students to carry out scientific experiments through the dry lab (computer experimentation).

EVALUATION OF SCIENCE CURRICULA IN BAHRAIN

The science curricula in Bahrain have undergone a continual process of reform from the start. However, was this reform accompanied by evaluation? It is known that curriculum evaluation is an attempt to shed light on two questions: do planned courses, programmes, activities, and learning opportunities as developed and organized here actually produce the desired results? And, how can the curriculum be best improved? (Curriculum Evaluation, 2013)

Two valuation studies were performed by the Arab Center for Educational Research in Gulf States (1996a, 1996b). One was on the unified science curricula for the intermediate stage (grades 7–9), and the other was on the unified science curricula for the primary stage (grades 1–6). But what about the current curricula? Although both Bahrain and Saudi Arabia adopted the same Arabic translated version of the US McGraw-Hill science series that covers the twelve grades of the schooling system, curriculum specialists in the two countries were asked to modify these textbooks to adapt to the cultural needs and issues of their own countries. However, I couldn't find any official evaluation of the Bahraini version in any form. Thus it is highly recommended that funds should be allocated for a comprehensive evaluation of these curricula with special attention given to cultural issues and meeting societal needs.

CONCLUSION

It is evident that school science curricula in Bahrain have undergone a continual process of modification that fits the cultural issues and changing societal needs. At the beginning of the 1960s, unified science curricula were adopted by Bahrain and Saudi Arabia. Currently, the ministries of education in these two countries have implemented the Arabic translated version of the McGraw-Hill science series curricula for all grades on their schooling ladders. The publisher Obeikan published and printed the modified versions of the textbooks for each of these two countries according to a three-year plan that ended in 2012. Instructional methods were also modified accordingly. The dry labs that accompany the new trend towards virtual learning were introduced in science teaching in Bahrain, primarily at the secondary school stage.

With this attention given to reforming and updating, an apparent defect was evident. Little concern was given to an accompanying evaluation. Research was not given enough attention compared with that given to initiatives and the development of educational projects. The concern that the Ministry of Education has for quality is no substitute for outside evaluation of curriculum reform. Quality assurance, which is currently followed for the assessment of Bahraini institutes including schools and universities, is not a guarantee of the success of newly implemented curricula. Thus, it is recommended that external evaluational research with a predetermined budget should accompany any reform or development of any programme, whether the science curricula or even a training course. The predetermined evaluation budget should be a part of the programme budget itself.

Another major problem that I suffered from during this study was the lack of cancelled science curricula and the accompanying textbooks previously used in Bahrain. The Ministry of Education in Bahrain should take care to document the previous curricula and the associated textbooks in a well maintained museum. The Department of Documentation at the Ministry of Education badly needs to establish such a museum for these textbooks even if they were cancelled; they remain a valuable resource to researchers and decision makers.

NOTES

1. The information in this section is based on an interview on 7th November 2012 with Dr. Abdelhameed Mahadeen who started his career as a teacher in public schools at the Ministry of Education in Bahrain in 1960 and wrote many documentary books about education in Bahrain.
2. The information in this section is based on an interview on 23rd October 2012 with Mr. Yousef Mahfoodh and Mrs. Kalthoome Bastaki. Mahfoodh has worked as curriculum specialist at the Ministry of Education in Bahrain since 1987 and now works there as a science curriculum consultant. Bastaki worked as a science teacher for 14 years from 1978, then as a head science teacher for four years, and after that she was promoted to head technology curriculum specialist, to date.
3. The information in this section is based on an interview on16th November 2012 with Mr. Abulrahman Nassar who worked as a science teacher. He mainly taught physics at public schools of the Ministry of Education in Bahrain from 1965 until retirement in 2010.
4. The information in this section is based on an interview on16th November 2012 with Mr. Abulrahman Nassar who worked as a science teacher, and mainly taught physics at public schools of the Ministry of Education in Bahrain from 1965 until retirement in 2010.

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6. A CONCEPTUAL FRAMEWORK FOR RE-SHAPING SCIENCE EDUCATION IN SAUDI ARABIA

ABSTRACT

Science education has progressed in the last two decades, particularly in Western countries, and a transformation has occurred away from teacher and textbook-centred toward student-centred learning. Science education in Western countries has moved to using a constructivist approach (i.e. a communicative approach with dialogue, discourse) that gives the opportunity for the use of students' previous knowledge and experience in understanding scientific concepts. Science education in the Arab countries in general and in Saudi Arabia in particular is still using traditional teaching methods which do not take students' participation and views into account and are mainly based on teachers and textbooks. This study seeks to provide a conceptual framework for developing and reshaping science education in in Saudi Arabia, with a particular focus on secondary education. This conceptual framework is based on the teaching sequence designed especially for this purpose and addresses the issue of science education from constructivist and socio-cultural perspectives. The designed teaching sequence was applied to Saudi secondary students and addressed different issues related to traditional and contemporary teaching methods. The study results indicated that the designed teaching sequence was effective since it used the communicative approach (interactive/dialogic approach) and shifted from a lecturer style (i.e. memorizing) to a conversational style. The study argued that the local Saudi society and culture affected students' understanding of scientific concepts which contradict with the scientific perspective. On the basis of the results, this study recommends designing new pedagogical strategies that centre on the communicative approach. The study also recommends that the local social and cultural issues should be taken into account in curriculum development.

THE CONTEXT OF THE ARABIAN GULF COUNTRIES

Science education has changed in the last few decades, particularly in the West. Western countries started using the constructivist approach in the last five decades, giving students the opportunity to use their previous knowledge and experience in understanding scientific concepts. The Arab world in general and Arabian Gulf countries in particular are still using conventional methods of teaching which are based on memorization (Hourani, 2011; Alhammad, 2008). Current textbooks are

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still designed to use traditional methods and are not suited for constructivist science education and teaching. The design of the textbooks does not take students' views into account. In other wrods, current textbooks have not taken students' ability to construct and present their ideas as well as exercises. Synder and Sullivan (1995) and Gallagher (1991) stressed that the textbooks are usually written in an authoritarian style that do not provide empirical experiments. However, the constructivist view suggests that the textbooks should provide experimental information in an efficient and effective way (Guzzettei et al., 1993). Hourani (2011) found in his empirical study on science education in the United Arab Emirates that schools do not apply the constructivist approach because classrooms are not equipped for cooperative learning and suffer from a lack of computers in the classroom. The study also indicated that teachers are unfamiliar with constructivist teaching strategies, including a lack of skills related to managing class discussion. Students in the Hourani (2011) study were not able to research or answer questions that required some thinking. The author attributed that to students' lack of synthesis skills and unfamiliarity with independent learning strategies.

In his study on the Arab Gulf countries, Litvin (2010) found that there is a large distance between students and teachers, since the teaching and learning processes are teacher-centred while students expect teachers to outline their learning path and teachers have all the answers to questions. The study also found that students expect to learn 'how to do' but not learn 'how to learn'. Litvin (2010) indicated that students form groups or pairs with friends on the basis of family or tribe. Students would not work in groups or pairs with some of the other students who did not belong to their family or tribe, but would help friends and share answers for doing homework.

In relation to the Saudi science educational context, Al Ghanem (2009) reported that the Saudi science curriculum has not been changed and does not take social values into account. However, Al Ghanem stressed that although social values should be reinforced and preserved, social ills should be identified, examined and coped with. Therefore, the designers of the Saudi curriculum should work on resolving problems and issues that require agreement within the science community. The first educational policy in Saudi Arabia was issued in 1969 and was considered as a foundation document for the education system in the Kingdom. Since then, no documents have reported or mentioned the essential use of the social constructivist approach in schools. Educational polices and plans in Saudi Arabia did not inspire the imagination of science curriculum designers to consider what ought to be done, and how it is to be done (Al Ghanem, 2009).

It can be concluded from this brief overview of literature on the Arab Gulf countries' relationship between social constructivism and science education that there is a lack of empirical studies that connect Gulf social and cultural aspects of life and science education. Students in the Arab world in general and Gulf countries in particular live in different environments and communities in which students have different sorts of experiences that may affect their daily life, including their understanding of scientific concepts. Therefore, this study aims to build a conceptual framework for reshaping science education on the basis of the empirical study conducted on Saudi secondary students.

THEORETICAL CONSIDERATIONS

It is essential in this study to firstly describe science teaching. Tseitlin and Galili (2005) describe science teaching as a triangle that consists of three main entities: science teaching (e.g. chemistry), phenomenon (e.g. in culture) and the concepts of science. Teaching approaches are moving from traditional to contemporary approaches that take into consideration students' background knowledge and thinking. New teaching approaches aim at creating a more responsive education that motivate students to keep themselves in tune with all aspects related to their social and cultural existence (Abell & Smith, 1994). This depends upon how students construct their knowledge depending on their background knowledge and culture.

There are several questions that may be posed in relation to students' daily lives. For instance, how do students match and connect between their everyday lives and science taught in school? How do students deal with cognitive conflicts and the world of science? What are the effects of these on effective science education? In relation to these questions, Baker and Soden (1997) studied the relationship between students' cultural backgrounds and formal school education. There is still a lack of literature on the connection between local culture and science education and no attention has been paid to students who live in communities that have different beliefs, values and practices from western culture, for example. The fact is that these traditional daily actions guide students' thinking to conceptualise their own concepts according to what they have learned from culture and practices (Snively & Corsiglle, 2000). George (2005, p. 1) states that education can incorporate traditional knowledge into the conventional science content. This means that researchers have realised the importance of culture in science education and how to link it when designing curricula. These studies suggest that cultural issues mainly exist in non-Western nations (developing countries) because people in such parts of the world (Saudi Arabia) are still connecting scientific issues to daily living to some extent. The students' knowledge system in this case is different from the traditional science taught in schools. This knowledge is primarily passed down verbally (not written) from older generations (parents and grandparents) (Jegede, 1995). According to Jegede (1995), even Western students from the United States and Europe sometimes use some kinds of knowledge not based on textbooks or what they learn in school. These examples reveal that science education should take students' background experience into consideration.

Students who are learning science may construct scientific concepts on the basis of their indigenous values, norms and expectations. Such students depend upon their conventional actions and the activities of their daily lives (Aikenhead, 1997; Cobern, 1996). Therefore, students face difficulty in moving between the culture of their daily life and the culture of science (Peat, 1994).

It is critical to review theories and models of learning that need to be understood, particularly by teachers when they think about teaching. In general, learning theory provides conceptual tools that may be used by teachers when they start the teaching process. In this particular study, it was necessary to use what is called social constructivism. The original strand of learning theory was suggested by Vygotsky and taken up by neo-Vygotskians because the learning theory focuses on social constructivism.

The main point in the constructivist model is its concern with how knowledge and knowledge acquisition are conceptualised. In other words, the constructivist view focuses on the nature of knowledge and how this knowledge is developed over time. Therefore, knowledge is primarily based on the theory of knowledge (epistemology) (Sandoval et al., 2000). In relation to this knowledge aspect, Atkinson (1999, p. 2) states:

> Knowing students individually also involves knowing them culturally… furthermore, such articulated knowledge of who students are individually-culturally leads logically to the need to develop appropriate pedagogies – approaches to learning and teaching that dynamically respond to their knowledge.

This statement reveals that the articulation of knowledge depends upon what students have accumulated from the cultural values and environment in which they live.

According to the social constructivist view, students are able to construct new knowledge on the basis of knowledge they have already gained from previous experience. According to Duit (1995), the knowledge already existing and students' prior conceptions may impede their learning because they build blocks against understanding new concepts, or these cause confusion in students' minds. Sometimes students' prior science conceptions are unambiguous and unmistakable and come into line with science conception. However, this is not always the case, since students may be confused about what is in their minds and in the textbooks. Therefore, the change from students' conception to science conception is not an easy task and sometimes is awkward due to the fact that students' previous knowledge on certain science concepts provides goggles (Brown & Clement, 1989). Although students may construct knowledge themselves, the construction process is always completed within the social and cultural settings.

Furthermore, Ackerman (1996) stresses that the social constructivist model focuses in general on different kinds of reasoning. For instance, these theories proceed from abstract to general, from externally supported to internally driven and from context-bound to context free. These aspects are embedded in expanding students' participation in the learning process in which students are able to develop their own ideas and construct new knowledge.

Although several studies have been conducted on constructivist theory and its application to education, it has not been used widely on science education in the Arab world in general and Gulf countries in particular. Therefore, the use of constructivism would guide the pedagogy and curricula design which should be centred on students in science education, that is, science that is oriented towards the needs and interests of students. Gulf countries have special circumstances that make them different from other communities in the world (see the context section above).

The theories that were approached included why was the social constructivist perspective used; and what is the relationship between the designed teaching sequence and the social constructivist approach (DiSessa & Cobb, 2004). Behaviourism, cognitive theory and socio-cultural perspectives are all examples of these theories (Siemens, 2006; Blackmore, 2007).

The majority of the influence was to be found only on social constructivism. The reason for this key focus is because the study was adapted to designing a teaching sequence and was first established on the Leeds Group Model. As stated previously, several researchers discovered that constructivism is a predominant viewpoint within ongoing debates on teaching and learning science (Driver et al., 1994a; Hodson & Hodson, 1998; Doolittle & Camp, 1999; Leach & Scott, 2003.).

It was implied by Merriam and Caffarella (1999) that constructivism takes learning to be a procedure of forming meaning. Likewise, how individuals make an appreciation of their experience and understanding. What guides students to a proficient understanding of phenomena? It depends on the student's ability to think in a rational and analytical manner (DeYoung et al., 2008).

Based on a constructivist perspective and in terms of designing a teaching sequence, one of the design tools is a communicative approach (Mortimer & Scott, 2003). It is thought of as a design tool that concentrates on classroom discourse (Leach et al., 2009). It was proposed by Hodson and Hodson (1998) that the constructive approach is correlated with several aspects, consisting of the recognition of student ideas; allowing students the prospect to discover and develop on their own ideas; encouraging students to exploit and adjust their ideas when necessary; and lastly maintaining their experiments to inventively recreate scientific ideas. Two elements portray the science behind the classroom discourse – the *authoritative/dialogic* and the *interactive/non-interactive*. According to Scott et al., 2006, it appears that an alteration occurs between authoritative and dialogic discourse via a succession of lessons in compliance with the aim of talking. There is an essential difference between authoritative discourse and dialogic discourse. In the authoritative discourse, the teacher usually regulates the debate that emphasises on one perception, whereas in the dialogic discourse, conversing is vulnerable to various perspectives including a combination of everyday life and scientific views. Then again, the collaboration method implicates more than one party; however non-interactive discourse is based on only one party.

It was noticed by Hodgson and Pyle (2010, p. 13), that students' incapability of expressing their ideas could have an adverse effect on their confidence and fails to generate a positive atmosphere within the classroom. However, it was determined by Mortimer and Scott (2003) and Chin (2007) that matters raised by teachers contribute a vital part in teaching science.

DESIGNED TEACHING SEQUENCE

This study (my study) aimed at building a conceptual framework for reshaping and designing new curricula for science education in the Arab Gulf countries. In order to achieve this objective, a teaching sequence was designed. The main purpose of this teaching sequence was to examine Saudi students' understanding of science concepts (e.g., concepts of matter; chemical and physical changes) using traditional teaching methods (which are currently used in the Saudi schools) and a communicative approach that follows constructivism. However, the teaching sequence did not differentiate between the changes at the sub-microscopic level[1] (i.e. atoms). This is because particle models[2] are not employed in explaining science phenomena in the Saudi textbooks. The designed teaching sequence was based on two key principles: Design Brief and Worked Example. The Design Brief aims to explicitly define the teaching sequence intentions for a piece of science teaching and explain why particular design decisions were taken. The Design Brief focuses on three aspects: the context of the designed teaching sequence; the content of the teaching sequence; and specification of the pedagogic strategies and sequencing of content. However, the Worked Examples teach activities addressed in the Design Brief including pedagogical strategies, so the focus is on knowledge about the teaching of specific content at the level of pedagogical strategies. Ametller et al. stated that "*pedagogical strategy is to indicate different ways of working on knowledge in order to address content-specific learning aims at a fine grain size"* (2007, p. 485).

Rationale for the Design of Teaching Sequences

It was indicated that most students have a deficiency in understanding scientific concepts. There is a great deal of research that proves the positive correlation between the teacher and the students' learning but without translating the results into plans and practices. The reason for this absence of putting the results into practice could be because there is a lack of research papers, which are generally articulated via high levels of abstractions (Andersson & Bach, 2005). Teaching sequence studies includes several features of academic practice (Andersson & Bach, 2005). It enables teachers and researchers to mutually discuss and agree, which increases the possibility that outcomes can be applied and assessed. Throughout the scheme of the teaching sequences, the subject matter will be examined to ensure a wide selection of topics has been selected and to the appropriate theoretical level. In the last part of the design procedure, the teachers were requested to apply the teaching sequence via precise guidelines. Constant observations were made for improvement of the scheme which permits for new models and concepts to be acquired (Andersson & Bach, 2005). The discussion above can conclude that the accomplished scheme of teaching sequence is a difficulty propelled by research that can be improved in order to enhance teaching practice and endorse student learning. For students to accomplish a certain objective, this enhanced teaching sequence has to be correctly used. This also allows us to construct a system whereby teaching and learning are heightened (Cobb et al., 2003).

Design Teaching Sequence Activity

The most sophisticated experimental design starts by conceptualizing the process through which planned outcomes and actions are identified. These outcomes are then embodied into a procedure (e.g., teaching sequence) that fulfils the purpose of enhancing the learning and teaching practices (Gorard & Taylor, 2004). Teaching and learning theories play an important role in the shaping and specifications of the designed teaching sequence. Designed teaching sequences are usually reviewed for the purpose of improvement and re-development of new guidelines (Cobb et al., 2003). This process leads to improve the effectiveness of the teaching sequence (O'Donnell, 2008).

It is worth remembering that developing and designing a teaching sequence is not a linear and straightforward process (Confrey, 2006). There are different steps that should be taken into account when deciding upon a teaching sequence. This process consists of the design stage, testing the sequence and evaluating the design. This process continues until an effective design (product) reaches a high level of understanding by practitioners (Lijnse & Klaassen, 2004).

Learning Theories and the Designed Teaching Sequence

Developmental theories of children generally involve grand theories. These theories are mainly used as a guide for the creation of the domain-specific theories and frameworks that entail conceptual analysis, justification of content and classroom activities. Specific design tools are created for the purpose of linking the grand theory and the practice of teaching. The generation of domain-specific theories requires creativity and skills to produce design models and tools in order to apply grand theories to serving specific purposes. The designing process is significantly informed by designers who have professional knowledge in teaching and are experts in learning methods. Students' ideas can also be utilised in judging and creating effective scientific representations (Mayer, 2002). However, grand theories have failed to be used in explaining learning processes in different environments. This failure has led to the development of domain-specific theories that acknowledge the importance of the content and context of learning (Mayer, 2002). It has been argued that there are differences between the epistemology and ontology[3] of everyday life and scientific reasoning. Furthermore, there are no simple rules for pedagogical practices that may emerge from the constructivist approach of learning (Driver et al., 1994b). Therefore, there should be special attention given when intending to design a teaching sequence. This may also include the difference between students' background (informal thinking) about a certain topic compared to the scientific view (Scott et al., 1992).

Researchers in the western world have anticipated concepts that aid in guiding the scheme of teaching (Andersson and Wallin, 2006). It was proposed by Ametller et al (2007) that specific schemes must be expanded upon the content and education in the design of teaching. Cobb et al, (2003) identified the domain-specific theories as 'humble'. These focus on precise learning procedures and classify patterns of students' perceptions so as to enhance learning. They were labelled 'humble' since they are responsible for offering guidance in organising commands. Domain-specific theories are applicable and efficient in practical educational theories.

Certain agendas and implements have been directed to the formation of such accomplishments, a transitional path between grand theory and the progression of designing a teaching sequence (Ruthven et al., 2009, p. 330). Hypothetical viewpoints have been induced by the design tools on teaching and learning; as have the outcomes of experimental research on teaching and learning with the intention of apprising design decisions at adequate 'grain levels' (Leach et al., 2009; Ruthven et al., 2009). Nevertheless, the creation of domain-specific theories is not a marginal theme. Originality and proficiencies are necessary in order to generate design models and tools so as to create grand theories to aid certain intentions (Gorard & Taylor, 2004).

The significance of expressing content-specific theories as regards the teaching and learning of certain topics was strongly emphasised by Lijnse and Klassen (2004). They recommended that these concepts can be in the structure of 'didactical structures' that can be functional to parallel topics. A very important component in this didactical structure is benefiting from a situation which validates the proposed and anticipated teaching and learning process. An additional theory is that of the learning request (Leach & Scott, 1995) which has been enhanced as an apparatus to notify the preparation of teaching. Thorough analysis is vital in order for the content to be efficient. It has been argued by Duit et al. (2005) that in evolving the teaching of precise science topics, distinctive courtesy must be given to the role of the teacher. This is fundamental since it assists in the combination of research with practice. Leach and Scott (2003) endorse the significance of the role of the teacher specifically when supporting students to adopt scientific ideas through discourse.

RESEARCH DESIGN

This study targeted Year 10 secondary students in Saudi Arabia. One public (governmental) school was selected to be investigated as a case study, and 90 male students who were aged 16 years took part in the study. Additionally, the only two chemistry teachers were chosen to implement the designed teaching sequence. The teachers were trained on the teaching sequence for two weeks and then trained on the communicative approach in the third week. According to Mortimer and Scott 2003, the communicative approach focuses on the interaction and participation of students in the classroom. Since the study used the communicative approach, it was necessary in the teachers' training to use video clips which included several examples to show the use of the communicative approach in the science classroom. The teachers who participated in this study used the interactive/dialogic method as a communicative approach in eliciting students' ideas about the change processes. Students worked in pairs and used the interactive approach which helped them share their ideas.

Three written tests (pre, post and delayed) were used. According to Driver and Erickson (1983), two types of analytical questions were applied in order to examine the students' theoretical interpretation of the teaching sequence. The two types are distributed into theoretical and phenomenologically centred questions. The theoretical questions aided in discovering students' appreciation of the taught chemistry contents whereas the phenomenological questions concentrated on the students' understanding of everyday situations.

Interviews were used in order to detect the diverse interpretations of the chemistry teachers and the way students looked upon the new teaching sequence in experimental clusters. The main objective of this was to clearly allocate learning complications and to thoroughly understand how the teachers' choices affected the students' learning (Millar & Hames, 2006). In addition to this, interviews were purposed to consider the students' and teachers' opinions about the unrestrained approach used to grasp scientific concepts. Ultimately it was also aimed to ascertain that students' understandings about the proposed teaching designed for the purpose of the study The task was accomplished using interviews with a model group of ten students in the experimental groups; also two teachers took part in the findings. This was applied after the teaching involvement.

RESULTS AND DISCUSSION

The results of the interviews with students found considerable differences between traditional teaching methods and the new communicative approach, since students reported that the new teaching intervention was more effective than the traditional teaching approach usually used by teachers. This was because the new designed teaching sequence was based on the interactive and dialogic approach. Students were in agreement upon shifting from the lecture style to the conversational style. Teachers' views were not different from students' in relation to the benefits of the new teaching design since they stated that the new approach gave students the opportunity and freedom to express their ideas. With respect to this issue, Hodgson and Pyle (2010, p. 13) stress that if students are not able to talk about their ideas their self-esteem will be affected negatively which does not create a good environment for learning in the classroom.

The results of the interviews showed that teachers will not be reluctant to use the designed teaching sequences in the future. Therefore, this requires teachers to be prepared for the use of a new design of curriculum. Ratcliff et al. (2006) assert that teachers are able to learn new things and divert from using one approach to another and change their practices as well as adjusting the pedagogical strategies according to the new teaching method.

In relation to the content of the designed teaching sequence, the results of the interviews indicated that the ability of students to identify the most prominent key scientific ideas in the designed teaching sequence aided them to familiarise themselves with the intervention and realise its strengths and weaknesses, particularly its scientific content. For instance, the analogy of billiard balls was employed to explain how particles were arranged in states of matter. Students reported that this did enable them to understand the definition of matter, along with the fact that 'air occupies space' which assisted their understanding of the concept of matter (Millar et al., 2006).

As for pedagogical strategies, the results of interviews conducted with students indicated that strategies consisted of students' previous ideas, student-student dialogue and discussion as well as speaking to teachers in the classroom. The interviews demonstrated a consensus that their knowledge exchange was appreciated and enabled students to talk about their ideas and discuss them with peers in the lesson. Despite the fact that this approach was effective, some students suffered distractions from other students in the class who did not participate seriously in the activities of the practical work and discussion. The disturbance from some students could be attributed to the designed teaching sequence which was new to them. Thus, students may need more time to acquaint themselves with the new intervention which includes student-student discourse. As mentioned above, Litvin (2010) found that students in class form groups on the basis of family or tribe which may hinder collaboration in the class and effectiveness in group working.

In terms of the analogical strategies, teachers taught students compressibility analogy which states that solids cannot be compressed due to the fact that their particles are touching and bonded. In order to understand this matter, sand was used as a solid state through which students could push their hands. This, in fact, contradicts the scientific view which states that students cannot push their hands through a desk, for example, because the particles are bonded. From Arab and Saudi culture and daily life, students can push their hands in the sand although this contradicts with the scientific perspective. This problem arose during the 'states of matter 'lesson which created trouble for teachers who ignored students' questions. In relation to this aspect, Stavy (1990) and Scott et al. (1992) mention the analogical relationship between known materials (e.g., desk, sand) and unknown materials (solid particles) which may help students to learn about new ideas and adjust their misconceptions and misunderstandings of some areas of knowledge. This was due to the newness of such ideas to students and their unfamiliarity with particle ideas (Gabel, 1999). According to Leach et al. (1995) students' ideas are affected by their culture and experience in relation to certain phenomena.

IMPLICATIONS FOR SCIENCE EDUCATION IN ARABIAN GULF COUNTRIES

The results of the study are important in formulating a number of implications that may be beneficial for educational authorities in the Arabian Gulf countries and help them in designing new science curricula. As mentioned above, this study was conducted at the level of Saudi secondary schools and the results may be generalised to the other Gulf countries since they have the same socio-cultural and environmental circumstances. This study addressed the issue of understanding science concepts (e.g., physical and chemical change) at the sub-microscopic level which, in fact, is not taught at primary levels in Saudi schools. Therefore, the educational authorities in the Gulf countries may develop a science curriculum that contains understanding scientific concepts at the sub-microscopic level. The second implication is to effectively use the dialogic method (Mortimer & Scott, 2003) which will help students to communicate and discuss their ideas with peers and teachers in the class through using previous knowledge. Therefore, educational authorities may work on reshaping current curricula by adding the communicative approach. In order to meet the requirements of this approach, it is necessary to allocate relevant resources, such as training teachers on the use of this approach, particularly in the long run. For example, schools may work on developing on-the-job training for teachers within schools or by the educational authorities (Millar et al., 2006; Ratcliffe et al., 2006).

There are several studies (e.g., Van Driel et al., 2001; Supovitz & Turner, 2000) which stress that teachers' development programmes in constructivism may affect the culture within the classroom, particularly in terms of students' participation. Teachers are required to be trained on pedagogic content knowledge (Shulman, 1986). Teachers' training and professional development may be centred on how to develop their knowledge of learning demands and different areas of the science curriculum (Leach et al., 2006).

Students in this study were asked, 'Is it possible to push your hands through your desk?' In general, this aspect was mentioned in the worksheet. Once students had tried to answer the question, it was confirmed by the teacher that students were not able to push their hands through the desk due to existing bonds that hold the solid particles strongly. The teacher concluded from this task that the size of the matter was kept because the bonds between the particles were strong which, in fact, matches the scientific view. It can be said in this case that the particles of matter are stationary and stable. In the case of a liquid state, the forces and bonds are not solid at all and particles slide easily so that the shape of matter takes its container. Similarly, the bonds and forces in the gas state are not strong at all and spread easily, and take the form of the container around it.

In terms of the teaching strategy (analogy), the teachers taught students compressibility analogy which states that solids cannot be compressed due to the fact that their particles are bonded. Teachers used sand as an example since scientifically, sand is assumed to be solid. However, students were instructed that it is not possible to push their hands through a desk due to the fact that particles are bonded while beginning to push their hands into a solid material. Sometimes students in Saudi Arabia are affected by socio-cultural values and their daily lives, therefore, they believe that they can push their hands into sand. This means that students are affected by a culture inherited from their parents and grandparents. This problem has arisen during the state of matter lesson. This also troubled the teacher who ignored the students' questions. According to Scott et al. (1992), and Stavy (1990), there is an analogical relationship between known materials (e.g., desk, sand) and unknown materials (solid particles). Although there was confusion about particles of solid materials, students could learn new ideas and have their misunderstandings or misconceptions of knowledge modified. It was clear that students' confusion was due to the fact that they were not familiar with particle ideas in chemistry teaching and this hindered their conceptual understanding of particle modelling (Gabel, 1999). It is worth remembering that Saudi Arabia has a different environment since it is a desert area. Sand analogy was not included in the Designed Brief. A cube of wood was used in the Designed Brief, contrasted with a syringe in compressibility. According to Leach et al. (1995), students' thinking about some phenomena may be affected by their previous experience and cultural background.

CONCEPTUAL FRAMEWORK FOR DESIGNING A NEW CURRICULUM FOR SECONDARY SCIENCE

This section presents the conceptual framework suggested for designing a new science curriculum for secondary education in the Arab Gulf countries. As mentioned above, this conceptual framework is based on the social constructivist approach and takes into account socio-cultural aspects of the Arabian Gulf nations.In the Arabian Gulf schools, a teacher conducts experiments while students watch him/her and memorize the steps, but students do not participate in the process. According to Taylor et al. (1997), this is a static process in which students do not use their capabilities or their knowledge. However, knowledge may be constructed through social and cultural interactions among individuals as well as from the physical environment (Yager, 1991). On the basis of this, educational authorities in the Gulf countries are required to design a new secondary science curriculum using the social constructivism approach that may create a change in science education.The socio-cultural aspects that must be taken into account consist of the Gulf society culture, national educational policies, how culture affects learning and how students are affected by the local culture. The constructivist perspective takes into account students' previous knowledge, the curriculum, how teachers teach and how students learn. All of these aspects should be taken into consideration when educational authorities in the Gulf countries begin to design a new curriculum. Once the curriculum is designed, it should be evaluated through involving students in the evaluation process.

CONCLUSION

In relation to the differences between the new teaching sequence and typical Saudi teaching, the results indicated that both students and teachers are satisfied with the new teaching sequence and considered it as superior to the typical teaching method used in Saudi schools. This was because the new approach focused on dialogic discourse in the classroom.

This study revealed that the local environment (desert) affects students' thinking about classifying materials. Saudi students who participated in this study were confused about what materials are solid and what are not solid in the example in which they had been taught that sand is a solid item in the compressibility activity. Nonetheless, the socio-cultural norm in the Arab Gulf countries including Saudi Arabia is to think that sand is not a solid material since they can push their hand into it. This is attributed to the fact that some people live near the sea and play with sand every day. In general, this fact contradicts with the scientific view which says that sand a solid material. This conclusion implies that when designing new curricula, designers should take account of the socio-cultural view.

The second conclusion of this study is that the new designed teaching sequence was based on dialogue discourse (Mortimer & Scott, 2003). This approach aids students to communicate and discuss their ideas with other students in the class as well as with the teacher. The results of this study implied that the decision to use the communicative approach by the educational authorities and teachers comes with recommendations to invest in the requirements of this approach, such as training teachers on how to communicate with students and how to motivate students to use their ideas and previous knowledge when discussing new concepts. This also requires more time allocated for discussion in the classroom. If these conditions are not taken into consideration by the teachers and education authorities, the traditional method of teaching will not be changed. Changing curricula and implementing new teaching sequences is not an easy task since these require commitment from the ministries of education in the Arabian Gulf countries, particularly in the long run with regard to the teachers' training, in schools or by the local educational authority (Millar et al., 2006; Ratcliffe et al., 2006).

NOTES

[1] Submicroscopic level describes the scientific phenomena based on particle level (Treagust et al., 2003).

[2] The particle model includes four aspects: (1) matter consists of particles; (2) there are spaces between matter particles; (3) the particles are in continuous motion; and (4) bonds exist between particles.

[3] Ontology is defined as 'the study of beliefs about the nature of reality' and epistemology is 'the study of beliefs about the origin and acquisition of knowledge' (Schraw & Olafson, 2008 p. 33).

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7. A CROSS-NATIONAL COMPARISON OF ICT RESOURCES AND SCIENCE TEACHERS' PROFESSIONAL DEVELOPMENT IN AND USE OF ICT IN THE GULF COOPERATION COUNCIL COUNTRIES

ABSTRACT

The development and spread of technology in schools as an educational innovation is well-documented worldwide, but the more recent and unique development of science instruction based on information and communication technology (ICT) has not been empirically examined in the Arabian Gulf, specifically. Using 2007 Trends in International Mathematics and Science Study (TIMSS) data, lower secondary science teachers' ICT professional development and use is investigated in this chapter to provide empirical evidence of a relationship between teachers' use of ICT for instruction, the spread of ICT resources in educational systems across the GCC, and the impact of these teacher and school-level characteristics on student achievement. Evidence from TIMSS 2007 suggests that teachers' use of ICT for instruction and engagement in ICT-related professional development in GCC educational systems is similar to the international mean, but having increased access to ICT in classroom instruction does not necessarily improve student achievement in science.

INTRODUCTION

What is the impact of technology use for teaching and learning in the Gulf? As nation-states worldwide shift their goals towards building knowledge societies and information-based economies, educational policymakers are re-evaluating the kinds of knowledge and skills students need (Ham & Cha, 2009; Kozma, 2005). This shift significantly influences curriculum development, teacher preparation and educational culture, especially in rapidly developing educational systems like those in the Gulf Cooperation Council (GCC) countries (Wiseman & Anderson, 2012; 2013). The incorporation of information and communication technology (ICT) in education across the GCC is coupled with the expectation that students' learning outcomes will increase as a result. This is difficult to confirm, however, since no empirical research has documented the extent to which information and communication technology policy transfer has spread in the GCC countries. Perhaps it is because the Gulf schooling context embodies unique social and cultural ideologies (Phillips &

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 137–152.

Ochs, 2003). For example, the intersection of strong religious ideology, rapid economic change, and developing social infrastructures broadly characterizes the Gulf educational context (Wiseman, 2005). Yet, the educational policies and goals in many GCC countries continue to focus on ICT without acknowledging the impact of social and cultural contexts (Dore, 2005).

As a result, economic and other national benefits are at stake in Gulf countries as they transition from natural resource-based economies to knowledge economies (ECSSR, 2010). Consultants and policymakers assert the importance of developing a knowledge economy in Gulf countries, not only for individual achievement but also for national economic development and international political legitimacy (Barber, Mourshed & Whelan, 2007; McKinsey, 2007). As a result, GCC countries have embarked on bold national experiments to increase student outcomes through the use of information and communication technologies (ICT) in education (Weber, 2010). For example, many GCC systems have borrowed from East Asian policy models (Dore, 2005) by implementing national policies and funding to enhance ICT resources for instruction including computer resources and technical support (Haddad & Draxler, 2002) and professional development to support teachers' implementation of ICT for student-centred, inquiry-based instruction (Cox & Webb, 2004; Richardson, 2011).

The transfer of ICT recourses and professional development policy scripts is a negotiated process of policy-borrowing and legitimacy-seeking, which is often de-coupled from local contexts and needs (Meyer & Ramirez, 2003; Phillips & Ochs, 2003). As a result, many countries seek to borrow their educational models and implement them at home. The problem is that these model educational systems developed in specific contexts, which are difficult to replicate in other systems. Many GCC countries, however, have initiated large-scale, national policy reforms to enhance schools' ICT resources and support teachers' professional development as a means to achieve student achievement outcomes. Research also suggests that instruction becomes more student-centred when teachers are trained to use ICT (Cox & Webb, 2004; Ilomäki & Rahikainen, 2007). But, there is less evidence suggesting that teachers' participation in professional development increases student achievement. For example, Wallace (2009, p. 588) found that professional development has only an "occasionally significant" effect on student achievement. Simply increasing teachers' access to ICT resources in the GCC may not mean teachers integrate ICT into instruction or adopt more student-centred pedagogies. But, as evidence shows, teachers – not resources – are the catalysts that improve student achievement (Ming et al., 2010). Therefore, purposeful ICT-related professional development for teachers is more likely to impact student learning outcomes than ICT resource availability alone.

As a result, Gulf educational policymakers reflect the policy-borrowing and legitimacy-seeking characteristics of most developing systems in that they identify which systems are high performing, borrow the models or characteristics that seem unique, and plant those models in their system. The widespread institutionalization of ICT infrastructure in schools, however, has not significantly changed the institutional contexts of teaching and learning in the GCC (Wiseman & Anderson, 2013), and this may be the result of a lack of teacher or student capacity to use ICT for teaching and learning or because of difficulties sustaining ICT-based instruction that does not align with national contexts or educational expectations. This research investigates the relationship between student learning outcomes and ICT use within and across each GCC country, considering the spread of ICT resources in schools, and teachers' professional development and use of ICT in science instruction.

DATA, RESEARCH QUESTIONS AND MEASURES

This study uses data from the 2007 Trends in International Mathematics and Science Study (TIMSS) to comparatively analyse the integration of ICT into science education and its impact on student learning among 8th graders in the GCC. Science achievement data as well as questionnaire data for participating students, classroom teachers and school principals contribute to the background, ICT, and teacher preparation data. Science-related data is used in the analyses reported here because the opportunities to use ICT-based instruction for inquiry-based and student-driven activity during science lessons are potentially more variable in science than in other subjects.

Approximately 59 countries including about 500,000 students worldwide participated in TIMSS 2007 (Olsen, Martin, & Mullis, 2008). All six GCC countries participated in TIMSS 2007 at the 8th grade level with the exception of the United Arab Emirates (UAE), which was represented by Dubai only. The data used in these analyses represent a sample of 8th grade equivalent students, teachers, and schools in each of the six GCC educational systems that participated in TIMSS 2007.

GCC educational systems have rapidly developed their ICT resource availability since 2000, because these resources are easy to acquire, represent globally-competitive resources for learning, and reflect the growing global interest in and access to technology (e.g., Zucker, 2008). In response, the first research question (RQ1) asks:

> RQ1: How has information and communication technology developed in GCC national education systems?

This question investigates the level of ICT infrastructure in schools (e.g., resources and technical support) in and across the GCC countries. This gives context both within and across the GCC. *ICT resources* measures the number of students per computer both by school (within country) and by system (cross-national). *ICT technical support* represents the degree of technical support available per school (0=none; 4=high).

Our prior research on the spread of information and communication technology in the UAE suggests that teachers use ICT for lower-order thinking in secondary mathematics and science classrooms (Wiseman & Anderson, 2011; 2013). Evidence also suggests that professional development activities for ICT adopters focus primarily on the practical – not instructional – applications of technology (Haddad & Draxler, 2002), including how to operate a whiteboard or properly store laptop computers. There is also evidence which confirms that technology-savvy students are more likely to use ICT for learning both at home and at school (Zain, Atan & Idrus, 2004). This leads to a second research question (RQ2) regarding the ICT capacity for teachers' professional development and use in the GCC systems.

> RQ2: Does teachers' participation in ICT-related professional development inform their ICT use for science instruction?

This question investigates the relationship between teachers' professional development and use of ICT in secondary science instruction. *Computer use for schoolwork* is a student-reported variable indicating the frequency students use computers for schoolwork both in and out of school (0=never; 4=every day). *Computer use in science lessons* is a student-reported indicator of the frequency they use computers in science lessons (0=never; 4= every day). *Teacher participation in ICT professional development* is a teacher-reported indicator of whether teachers had participated in professional development aimed at using ICT for education (1=yes; 0=no).

The third research question (RQ3) asks about the ways secondary science teachers in the GCC countries use ICT to support student-centred learning.

> RQ3: Do secondary science teachers in the GCC use ICT to support student-centred learning?

Student-centred, inquiry-based learning is a characteristic of ICT-integrated instruction, but GCC educational systems are not necessarily associated with student-centred learning. As a result, ICT resources may be available for Gulf teachers' instructional use, but teachers may not have access to professional development to use ICT to support student learning

Indicators of student-centred learning with ICT include a percentage of teachers using computers for (1) practising skills and procedures, (2) studying national phenomena through simulations, (3) processing and analysing data, and (4) doing scientific procedures or experiments.

As these research questions and prior evidence suggest, in order for educational systems to capitalize on the benefits of ICT, teachers must have adequate resources and be trained to effectively incorporate ICT in all facets of their teaching to engage students in the process of learning (Gotas, Yildirim & Yildirim, 2009). Evidence also suggests that integration of ICT using an inquiry-based pedagogical model can act as a catalyst of pedagogical change with the potential to increase student-centred instruction in formal learning environments (Zhang, 2010). However, since ICT resource development is relatively new in the GCC context, we expect that teachers' engagement in ICT-related professional development may relate more with how to use available resources rather than to use them purposefully to support student-centred instruction in science. This leads to a fourth research question (RQ4) which asks:

> RQ4: Does teachers' professional development and use of ICT in science instruction support student achievement in science?

Even if schools across the GCC countries have increased ICT resources and professional development opportunities for teachers to use ICT for instruction, there is no guarantee of improved student learning as a result. For example, prior research suggests that teachers trained to incorporate ICT in instruction tend to use ICT-based instruction in ways that result in higher student performance (Plomp, Anderson, Law & Quale, 2003). However, the unique context of schooling in the Gulf may lead to different results, which is why the analyses below are needed.

METHODOLOGY AND RESULTS

The analyses reported here begin with univariate and bivariate analyses at the nation-level to describe cross-national trends in ICT resources and support (i.e., RQ1), teachers' ICT-related professional development (i.e., RQ2), and teachers' ICT use for science instruction (i.e., sustainable practice; RQ3). These analyses contextualize the effect of the spread of ICT in Gulf national education systems by taking into account school, teacher and student background characteristics.

Contextualizing cross-national survey data requires multilevel, multivariate statistical modelling (e.g., hierarchical linear modelling) that incorporates contextual variation into nested individual models (Raudenbush & Bryk, 2002). Multilevel regression models estimate the impact of smart school indicators on student achievement (RQ4), accounting for other contextual and background characteristics. These characteristics include indicators of student gender, student language, student socio-economic status, teacher gender, teacher age, teacher experience, and teacher education level.

Student gender is measured as *female student*, which is an indicator of whether a student is female. This variable ranges from 1 (female) to 0 (male) (Mean = 0.49, SD = 0.50). Approximately 49% of the GCC students sampled are female. This is a significant student-level variable to include in this analysis because of the likelihood of gender-segregated schooling in the GCC and the demonstrated contextualized effect of this kind of single-sex education on student performance levels, in GCC educational systems in particular (Wiseman, 2008).

Student language is measured as *language of test spoken at home*, which is a proxy measure for socio-economic status and the students' background context. Language of test spoken at home ranges from 0 (never or almost never) to 3 (every day) (Mean = 2.24, SD = 1.00), and is important to include as an indicator of students' national or non-national status in each GCC nation. As Kapizewski (2001) and Wiseman (2011) show, the national origin of Gulf individuals associates with their potential labour market opportunities and productivity, as well as their educational performance.

Student socio-economic status is measured as *books in the home* (Mean = 2.69, SD = 1.26), which is an indicator that also serves as a proxy measure and ranges from 1 (none or few books) to 5 (more than 500). While some assert that technological advances worldwide make books in the home a less-relevant indicator of economic status or household income, the number of books in the home measure on TIMSS remains a strong predictor of student achievement in the Gulf, and in many other developing-yet-technologically-savvy communities (Constantino, 2005).

Female teacher is a dummy variable indicating whether teachers are female, which ranges from 0 (no) to 1 (yes) (Mean = 0.50, SD = 0.50). In GCC education systems, schools often segregate by gender into single-sex schools or classrooms. This variable estimates girls' advantage in preparing for or demonstrating their capacity for student achievement in school due to the gender segregated versus coeducational nature of their schools and classrooms. *Teacher experience* (Science N=511) is another indicator of teacher background characteristics, which provides a measure of the number of years a teacher has been teaching. This variable ranges from 0 years teaching up to 37 years teaching (Mean = 10.67, SD = 7.40), and was a direct response measure provided by teachers. *Teacher education level* is a measure of teachers' highest level of educational attainment using the ISCED levels. This variable ranges from 1 (not completed ISCED 3/upper secondary education) to 6 (finished ISCED 5a, second degree or higher/post-graduate tertiary degree) (Mean = 5.01, SD = 0.40).

DESCRIPTIVE AND BIVARIATE ANALYSIS RESULTS

The first research question (RQ1) asks to what extent has information and communication technology developed in Gulf national education systems. In order to answer this question both the availability of computer resources and technical support for computer-based learning were calculated for each GCC country participating in TIMSS 2007. The results of a one-sample t-test for both of these indicators indicate whether the GCC countries were statistically significantly different from the GCC mean and international mean.

The international mean for the number of students-per-computer available for instruction in each of the TIMSS 2007 participating countries is 42.48, which is about 42–43 students-per-computer in schools worldwide; whereas the GCC mean is 36.57, which is about 36-37 students-per-computer. Students-per-computer ratios are significantly below the international mean ($t = -3.53$, $p<.001$) for all GCC countries; however, the ratios for Bahrain, Dubai (UAE), Kuwait, Oman and Saudi Arabia all cluster near the international mean with ratios ranging from 30.21 to 37.81. This equates to roughly one computer for every 30-38 students in the GCC countries. Qatar was significantly below both the international mean and the other GCC countries at 20.60 students-per-computer. The exception of Qatar being significantly different on the computer availability indicator suggests that instructional technology is more widely available for teaching and learning in Qatar than in most other GCC countries, even though Qatar's student performance average is among the lowest worldwide.

Another measure of ICT resources in schools is the availability of technical support. This support indicator ranges from 0 (no support) to 4 (high support) and has an international mean of 1.52. None of the GCC countries were significantly different from the international mean, except for Saudi Arabia. Saudi Arabia's ICT support indicator was among the lowest worldwide at 0.73 ($t = -61.53$, $p<.001$). Saudi Arabia's unique difference from the international mean may suggest that Saudi educators are more aware of the resources they need to implement computer-based learning in Saudi schools rather than that there is a significant shortage of resources and support. Either way, these results suggest that Saudi educators are under-supported in terms of what they perceive they need in order to provide ICT-based instruction.

To highlight whether ICT infrastructure is enough to transform student learning, average 8th grade student science achievement was correlated with the two ICT infrastructure indicators of computers-per-student and technical support for the international sample and individual GCC countries. Students-per-computer is negatively and significantly associated with science achievement in the international sample ($r = -0.231$, $p<.01$). It is, however, positively and significantly associated with science achievement in the GCC countries overall ($r = 0.068$, $p<.01$) and Saudi Arabia individually ($r = 0.107$, $p<.01$), but not significantly associated with any of the other GCC countries individually. By contrast, technical support was positively and significantly associated with science achievement in the international sample ($r = 0.163$, $p<.01$), Malaysia ($r = 0.084$, $p<.01$), Bahrain ($r = 0.421$, $p<.01$), and Oman ($r = 0.234$, $p<.01$). Technical support was negatively and significantly associated with science achievement across GCC systems ($r = -0.078$, $p<.01$), Qatar ($r = -0.326$, $p<.01$) and Saudi Arabia ($r = -0.190$, $p<.01$), but not significantly associated with science achievement in Kuwait or Dubai (UAE).

These results suggest that changes in ICT resources in schools may associate with student achievement in the GCC and worldwide; however, the GCC context presents a unique case for analysis. The variation in significance, strength, and direction of association for the students-per-computer indicator and the mixed results of association with technical support in individual GCC educational systems suggests that the impact of ICT for education is perhaps more complex in the GCC than in other regions.

An analysis of average 8th grade student science achievement scores by frequency of computer use for schoolwork and in science lessons serve as indicators of teacher and student capacity for smart schooling, which addresses the second research question (RQ2). While there is some variation among the countries' science scores relative to each other, the frequency of computer use for schoolwork positively associates with some computer use for schoolwork (e.g., "a few times per year"). It drops steadily for more regular computer use for schoolwork with students who report using computers for schoolwork "every day" scoring lower than those who report "never" in Dubai (UAE), Oman, Kuwait, and Saudi Arabia. Only students in Bahrain show a net gain in science achievement between "never" using computers for schoolwork and using them "every day".

The results for science suggest that the more computers are used for science lessons in every GCC country, the lower students' science achievement scores go. There is little improvement in science achievement from "never" using computers in science to "some lessons" versus more computer use in science lessons (e.g., "every or almost every lesson"). All computer use in science lessons is associated with lower science achievement scores in all GCC countries.

Although the TIMSS 2007 teacher background data does not provide information about ICT-related training received during pre-service teacher education, it does provide an indicator of whether teachers participate in professional development aimed at using ICT for education. In every GCC country except for Saudi Arabia, the modal response category was that 51–75% of teachers participate in professional development related to ICT. In other words, while it was significantly less frequent in the GCC for all teachers in a school to have participated in ICT-related professional development, it was most common for "most" of the teachers in a school to have participated. This indicated that many but not most science teachers in GCC schools had some training in using ICT for instruction. As a GCC outlier on this measure, Saudi Arabia's relatively flat distribution across each of the response categories suggests that there is a significant variation in the percentage of teachers in schools across Saudi Arabia that participated in professional development aimed at using ICT for instruction.

The third research question (RQ3) focuses on whether there are differences in ICT-based instructional use among those GCC teachers who had ICT-related training. This question asks whether GCC teachers' participation in ICT-related training or professional development activities associates with their use of ICT-based instruction, and if the resulting instruction is more sustainable for student-centred, inquiry-based learning. Although there is significant variation among the types and frequencies of computer use for instruction, all of the instructional purposes are mostly part of "some lessons". In particular, of the four instructional purposes listed, students using a computer for "practising skills and procedures", which is a fairly low-level instructional activity, is the most frequently used "every or almost every lesson" (15.4%). Students using computers for "studying natural phenomenon through simulations" and "for doing scientific procedures or experiments" are the most reported instructional purposes of computers in the classroom overall (52.6% and 52.4%, respectively) although the mode of computer use for these purposes is only "some lessons". Students report "never" using computers for "processing and analysing data" more than any of the other computer use for instruction categories. In other words, GCC science teachers use computers more frequently to "practice skills or analyse data" even though applying science knowledge during "some" of the lessons is the most frequent response.

Our final research question (RQ4) asks if there is a relationship between ICT instructional use and teachers' participation in ICT-related professional development activities, and whether that relationship impacts student science achievement. While many teachers participate in ICT-related professional development, increasing levels of professional development in ICT is associated with no or a somewhat negative change in student achievement scores. An analysis of 8th grade student science achievement in GCC countries, plus Singapore and Malaysia, by percentage of 8th grade teachers involved in ICT-related professional development shows that science achievement is either not significantly or is negatively associated with teacher involvement in ICT-related professional development. For example, in every GCC country except Oman, average student achievement dropped as soon as the percentage of teachers involved in professional development for ICT education shifted from "none" to "<25%". In the case of Qatar, student achievement continues to drop the more teachers in a school participate in professional development in ICT. These results suggest several possible explanations. Either teachers are poorly trained during these professional development sessions, or there is an effort to train teachers who already work with poorly performing students or to purposefully place ICT-trained teachers with poorly performing students in GCC countries, perhaps hoping that ICT-based instruction will help them improve.

HLM MODELS AND RESULTS

Finally, a two-level hierarchical linear model (HLM) estimates the impact that ICT-related teacher professional development has on the frequency of ICT-based instructional activity and student achievement, while accounting for both student and teacher background and school context. To capture the contextual effects of teachers most comprehensively, teacher variables are aggregated to the school level for the multilevel analysis. Since nationally representative samples of schools were selected in TIMSS and then teachers within those schools were selected, it is appropriate to estimate teacher variables aggregated to the school level. This procedure estimates ICT-related effects on students' science achievement in each of the GCC countries, and the GCC overall. Table 1 describes the variables used in this HLM analysis, and Table 2 provides the HLM results.

The first level of the model (1) estimates the amount of variance in students' achievement explained by student-level characteristics and student-reported ICT resource availability and use.

$$Y_{ij} = \beta_{0j} + \beta_{1j}\text{Female}_{ij} + \beta_{2j}\text{Language}_{ij} + \beta_{3j}\text{Books}_{ij} + \beta_{4j}\text{ComputerUseSchlwrk}_{ij} + \beta_{5j}\text{ComputerUseSciLssns}_{ij} + r_{ij} \quad (1)$$

where Y_{ij} is the TIMSS 2007 measure of student science achievement for the i^{th} student in the j^{th} school, and r_{ij} is a student-level residual. Note that all of the regression coefficients in the student-level equation (the βs) are indexed by j,

Table 1. Variable means by level and country/group (TIMSS 2007)

				1			
	Bahrain	**Kuwait**	**Oman**	**Qatar**	**Saudi Arabia**	**UAE (Dubai)**	**GCC**
Student-Level Variables	*N=3612*	*N=2172*	*N=3088*	*N=6236*	*N=2519*	*N=1799*	*N=22942*
Computers Used in Science	0.62	0.89	0.89	0.87	0.66	0.77	0.79
Lesson (Table ? 5)	(0.97)	(1.14)	(1.02)	(1.14)	(1.04)	(1.01)	(1.07)
Computers Used for	2.04	1.65	1.96	1.80	1.52	1.82	1.80
Schoolwork (? 4)	(1.27)	(1.41)	(1.29)	(1.44)	(1.39)	(1.20)	(1.36)
8th Grade Science	473.43	423.80	428.09	323.10	412.59	493.51	410.14
Achievement Score (Y)	(84.41)	(88.51)	(92.59)	(124.83)	(80.77)	(97.29)	(115.73)
Female Student (? 1)	0.47	0.54	0.50	0.52	0.52	0.54	0.52
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Language (? 2)	0.90	1.00	0.99	0.69	1.00	1.00	0.90
	(0.30)	(0.00)	(0.11)	(0.46)	(0.00)	(0.00)	(0.30)
Books in Home (? 3)	2.79	2.42	2.63	2.87	2.50	2.75	2.70
	(1.22)	(1.23)	(1.19)	(1.32)	(1.22)	(1.22)	(1.26)
School-Level Variables	*N=71*	*N=98*	*N=118*	*N=58*	*N=133*	*N=54*	*N=697*
Professional Development in	0.66	0.43	0.20	0.54	0.32	0.69	0.58
ICT for Science Instruction	(0.38)	(0.50)	(0.39)	(0.44)	(0.47)	(0.41)	(0.45)
(? 51)							
Female Teacher (? 01)	0.51	0.49	0.47	0.56	0.49	0.63	0.52
	(0.49)	(0.50)	(0.50)	(0.50)	(0.50)	(0.43)	(0.48)
Teacher Age (? 02)	3.09	3.23	2.16	3.24	2.88	3.26	3.14
	(0.64)	(0.95)	(0.85)	(0.84)	(0.74)	(0.90)	(0.94)
Teacher Experience (? 03)	11.60	12.64	6.60	12.83	10.13	13.23	12.14
	(5.40)	(7.72)	(5.48)	(7.60)	(5.89)	(7.62)	(7.48)
Teacher Education Level	5.05	5.08	4.97	5.10	4.95	4.97	4.96
(? 04)	(0.47)	(0.28)	(0.41)	(0.28)	(0.38)	(0.28)	(0.58)

[1]Standard deviations in parentheses

indicating that within the multilevel model a student-level regression coefficient is estimated for every j^{th} school in the sample. The term β_{0j} is an estimate of an adjusted dependent variable for the j^{th} school. The coefficients β_{1j}, β_{2j}, and β_{3j} represent the effects of student background and socio-economic status on science achievement. The coefficient β_{4j} represents the effects of student-reported computer use for schoolwork, and β_{5j} represents the effects of student-reported computer use in science lessons or for schoolwork, which is the key smart schooling indicator at the student level.[1]

The second level estimates the amount of variance in students' achievement that is explained by the student-level and student-reported characteristics when variance in school-level characteristics is accounted for as well as the effect of each school-level variable on the average science achievement score. The second level (2a) of this multilevel model includes the school-level factors as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{FemaleTeacher}_j + \gamma_{02}\text{TeacherAge}_j + \gamma_{03}\text{TeacherExperience}_j + \gamma_{04}\text{TeacherEducation}_j + u_{0j}, \quad (2a)$$

where γ_{00} is the science achievement indicator school mean, and u_{0j} is the school-level residual. The coefficients γ_{01}, $\gamma_{02}\ldots\gamma_{04}$ represent the school-level effects of teachers' background characteristics and are school level predictors of science achievement. The second level (2b) of this multilevel model further includes the following:

$$\beta_{5j} = \gamma_{50} + \gamma_{51}\text{PDinICTforSciInstruction}_j + u_{4j}, \tag{2b}$$

where γ_{50} is the mean indicator for the school-level effect (β_{5j}) of "computer use in science lessons" on student science achievement, and u_{5j} is the residual difference between the school- and student-level impact of this indicator. By estimating the impact that professional development in ICT for science instruction (γ_{51}) has on the estimated effect of "computer use in science lessons" (β_{5j}) on individual level student achievement (Y_{ij}), this multilevel effect provides an estimate of the overall impact of ICT infrastructure, capacity, and sustainable practice on student learning outcomes, which is the key indicator related to RQ4.

Table 2 shows the estimation of several contextual variables on 8th grade science achievement scores, but the most interesting predictor variables are "computer use

Table 2. HLM results by country (TIMSS 2007)

Y = 8th Grade Student Science Achievement Score	**Bahrain**		**Kuwait**		**Oman**		**Qatar**		**Saudi Arabia**		**UAE (Dubai)**		**GCC**	
Student-Level Variables														
Computers Used in Science Lesson $(^{2}{}_{5})$	-18.92	***	-18.77	***	-21.54	***	-23.04	***	-14.29	***	-12.97	**	-21.42	***
	(2.61)		(1.71)		(1.76)		(2.66)		(1.90)		(4.57)		(0.91)	
Computers Used for Schoolwork $(^{2}{}_{4})$	1.49		-2.20		-4.59	***	0.01		-5.71	***	1.88		-0.58	
	(1.03)		(1.32)		(1.21)		(1.07)		(1.16)		(1.64)		(1.04)	
Female Student $(^{2}{}_{1})$	7.46		-9.26		5.47		20.37	*	39.20	*	6.08		47.01	***
	(4.86)		(18.77)		(11.84)		(9.20)		(16.22)		(6.21)		(3.22)	
Language $(^{2}{}_{2})$	-7.17		.		17.33		133.05	***	.		.		125.88	**
	(11.23)				(34.67)		(16.83)						(43.52)	
Books in Home $(^{2}{}_{3})$	10.88	***	5.25	***	12.03	***	10.43	***	10.86	***	11.83	***	13.01	***
	(1.24)		(1.40)		(1.29)		(0.91)		(1.03)		(1.93)		(1.15)	
Intercept $(^{2}{}_{0})$	467.91	***	427.30	***	364.17	***	241.16	*	320.26	***	716.30	***	443.22	***
	(41.04)		(74.66)		(56.51)		(100.90)		(54.53)		(110.26)		(72.42)	
School-Level Variables														
Professional Development in ICT for Science Instruction $(^{3}{}_{51})$	0.78		1.63		4.11		4.74		4.37		3.00		1.87	
	(4.05)		(2.71)		(3.54)		(3.33)		(3.39)		(5.40)		(2.10)	
Female Teacher $(^{3}{}_{01})$	37.65	***	55.94	**	36.87	**	36.83	*	-2.56		33.63		9.32	
	(7.26)		(20.02)		(12.83)		(15.47)		(16.51)		(19.01)		(15.45)	
Teacher Age $(^{3}{}_{02})$	-2.07		7.28		6.83		-4.83		-6.54		-5.62		-32.28	**
	(6.51)		(5.31)		(5.80)		(11.18)		(5.88)		(16.58)		(10.40)	
Teacher Experience $(^{3}{}_{03})$	1.22		-1.22		-0.59		0.28		1.13		1.59		6.22	**
	(0.78)		(0.71)		(0.88)		(1.15)		(0.82)		(2.28)		(1.62)	
Teacher Education Level $(^{3}{}_{04})$	-8.09		-6.16		1.98		-8.32		13.93		-56.17	*	-25.19	*
	(6.91)		(14.71)		(7.99)		(18.43)		(10.79)		(22.50)		(9.76)	
Variance Components														
Level 2 (u_0)	611.77		1022.02		891.24		1496.35		685.63		3403.28		1798.70	
Level 1 (r)	5263.81		5509.91		6311.37		7714.42		4698.48		5132.83		8031.69	

[1]Standard errors in parentheses
*p<.05, **p<.01, ***p<.001

in the science lesson" and "computers used for schoolwork" at the student level and "professional development in ICT" at the school level. Interestingly, when estimating student science achievement, the significant (and frequently negative) impact that being female has on achievement in international studies is absent among GCC countries at both the student and school (in this case, teacher aggregate) levels (β_{1j} and γ_{01}). This is a unique contextual effect linked to the GCC practice of separating boys' and girls' schooling and to the different opportunities available to boys versus girls outside of school.

The proxy indicators for socio-economic status (i.e., "books in the home" and "speak language of test") are positive and strong predictors of student science achievement in the total GCC sample as well as each individual GCC system for books in the home. Socio-economic status indicators are traditionally strong predictors of student achievement worldwide, and are necessary to statistically account for background and contextual variation at the student and school levels. Mean teacher experience at the school level is a positive predictor of science achievement in the GCC overall ($\gamma = 6.22$, $p<.01$) even if not for each GCC country individually. However, the predictors of interest show some surprising results. Computer use for schoolwork is either not a significant predictor or is a negative predictor of student-level science achievement in every country included in this analysis.

"Computers used in science lessons" is more consistently, strongly, and significantly negative in its impact on student science achievement across the GCC than any other variable in the model, except for books in the home (β_{3j}). These results show that the frequency of computer use in science lessons is a strong, negative predictor of science achievement in the GCC. When science teachers in GCC countries use ICT-based instruction during their science lessons, students perform significantly lower than when they do not use computers.

To determine if ICT-related professional development impacts the strong, negative effect of computer use on student science achievement, the school level indicator of ICT-related professional development was used to estimate the coefficient for this relationship (β_{5j}). As Table 2 shows, teachers' professional development in ICT is not a statistically significant predictor of this relationship in any GCC country, nor across the GCC countries. This suggests that ICT professional development in the GCC may be focused on training teachers to use available ICT resources, but not how to use them to increase student achievement.

DISCUSSION AND POLICY SIGNIFICANCE

This research shows that the steady expansion of ICT in education worldwide – and the Gulf region's national education systems specifically – can be investigated using narratives of national policies and reforms as well as contextualized, cross-national assessments of educational achievement. The analysis presented here provides four main findings, which reflect the four empirical research questions. The analyses above suggest that the answer to the first research question (RQ1) is that the ICT resources and support systems do impact student learning, but that this impact is not significantly different in the Gulf Cooperation Council countries from the international trend.

As the key infrastructure indicators, computer resources for students and technical support in schools, suggest technical support seems to make more of an impact on student learning outcomes than computer availability. In other words, there may be a threshold in which a minimum number of computers in school is enough, but the availability of technical support for ICT-based instruction and learning has a more significant impact. The estimated association between technical support and student science achievement was significantly negative or not statistically significant in four out of six GCC systems (and negative albeit small in the total GCC sample). The policy significance of these findings is that ICT infrastructure considerations in GCC educational systems should be about more than providing technology for students and teachers to use, but extend to the importance of providing infrastructure for building capacity as well.

The second finding (RQ2) is that ICT professional development for teachers does not significantly impact their use of computers during science lessons, or increase student achievement. The evidence does suggest, however, that use of computers in science lessons across the GCC countries is consistently and negatively associated with student science achievement. In spite of the policy take-away from RQ1 that providing the resources and support for building ICT capacity at the school level is important, the findings for RQ2 show that in GCC countries, the more teachers participate in professional development there is no significantly measurable effect on student learning outcomes.

From a policy perspective, the RQ2 findings do not necessarily mean that teachers should stop receiving professional development for ICT, but that perhaps this is a result of teachers' existing lack of awareness about or skills for using ICT in instruction. In other words, the teachers receiving the professional development may be particularly traditional in their teaching methods in the first place meaning that they may have difficulty or actively resist using ICT-based instruction in spite of the professional development opportunities. It could be a teacher cohort effect as much as an effect (or non-effect) of professional development for using ICT for education.

A third finding (RQ3) suggests that ICT- and computer-based instruction is touted as a way to shift teachers and teaching away from rote memorization and traditional teacher-centred instruction towards inquiry-based and student-centred pedagogy. But, without appropriate readiness and capacity-building, teachers may be unable to fully utilize these resources for instruction. The evidence examined here suggests that simply providing resources, support and training in ICT for education is not sufficient to positively impact teaching and learning in the GCC countries, and that ICT-based instruction is not a guarantee of higher student achievement.

The policy significance of these findings is that ICT is a tool like any other instructional resource. It would be rare for national education policymakers and school administrators to recommend that teachers should use other technology tools (e.g., televisions, videos, or calculators) with students every day. Likewise, the findings of our analyses suggest that a little ICT use goes a long way. Targeted and strategic use of ICT-based instruction has a significant impact on student learning outcomes. The restrained and focused use of ICT may be the best policy recommendation for instructional use, especially in the classroom.

Our fourth finding (RQ4) is that supportive organizational contexts and high levels of student motivation (i.e., local context) are equally important. This finding is specifically important for GCC policymakers who advocate for school adoption as a means to increase student achievement. Rather than positioning ICT as a vehicle to improve student achievement as measured by international testing programmes (e.g., TIMSS), the potential of ICT in instruction lies in students' development of higher order thinking and problem-solving skills, which may not be appropriately measured by standardized tests. The fact that teaching teachers to use ICT does not directly nor consistently improve student achievement in situations where computers are used for instruction is a valuable policy lesson. One policy lesson that can be inferred from the results reported here is the need for education policymakers in the GCC to consider that although increased ICT resources, support, and professional development may not automatically increase student achievement as measured by assessments like TIMSS, it may still increase students' development of creative, problem-solving and communication skills, and these skills may support the knowledge society development goals articulated by these countries beyond simple science scores.

As the findings in response to the research questions posed here show, ICT resources, support, and teachers' professional development and use of ICT in schools and classrooms is not a guaranteed solution to teaching and learning challenges in the Gulf Cooperation Council countries, nor more broadly worldwide. So, on one hand, GCC education policymakers recognize the global expectation that governments should invest in technology infrastructure to support students' human and social capital. While on the other hand, the widespread institutionalization of ICT resources in schools does not automatically change the institutional contexts of teaching and learning.

The GCC's national educational development plans reflect the need for teachers to be highly trained content area specialists, fluent in the use of ICT resources and able to incorporate them into their classroom practice to positively impact student achievement. Perhaps the overly positive expectations for ICT in education result from the policy discourse in and about the GCC. The question is whether GCC policymakers, educators, students and communities are committed to realizing this goal even if increased student achievement does not immediately follow.

NOTE

[1] The independent variable for "language" was omitted for Kuwait, Saudi Arabia, and Dubai (UAE) because of the lack of variation among student-level responses.

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PART 3

THE SOCIOCULTURAL ISSUES OF THE SCIENCE EDUCATION IN THE ARAB GULF STATES

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8. SCIENCE EDUCATION IN SAUDI ARABIA

A Response to Controversial Issues

INTRODUCTION

Science education in Saudi Arabia has witnessed a substantial call to action to respond to the aims and challenges of the twenty-first century. Science curricula across all the 12 educational grade stages have been reformed (Alriyadh, 2008), and an official document outlining the national professional standards (NPS) including science disciplines is being developed cooperatively by TATWEER (King Abdullah bin Abdulaziz Public Education Development Project) and Qiyas (National Center for Assessment in Higher Education). Scientific literacy has become a core part of science education standards reflecting strong ties between science and society. The growing relevance of science and technology to society is evident. However, the intersectional area of science and society is debatable.

The advancement of scientific knowledge and technological innovation has revealed many concerns of how this breakthrough will be manifested for good or bad. In fact, the contribution of science has arisen concerns to maintain the good human society and to be coded with ethical and moral domains. Ibn Khaldun (reprinted 1971), a well known Arab Muslim historiographer and sociologist, has stated that the disturbance of the value system will lead to the corruption of urbanization and interruption of the human species. He also claims that the determination of any unjust act on urbanization is banned, and evidence from the Quran and Sunnah (what has been narrated from the Sayings of the Prophet Muhammed) induce supportive arguments that are anchored to mankind's actions.

Education bears a role to develop students' moral and ethical reasoning, and reconstruct students' epistemological styles to be able to decide on various socioscientific issues. Chang (1994) described teaching as moral by nature implying that the essence of a good teaching is denoted with the ethical and moral development by students. The moral and ethical system in the Islamic world is stemmed significantly from the Islamic doctrine. Mansour (2011) reported that even teachers' personal Islamic beliefs impact their views of the nature of science and its goals. The personal beliefs of either teaches or students will shape their ethical/moral system which may lead to a deficit view of the relationship between science and society. Therefore, Mahdi (2010) illuminated the distinction between a religious belief and a scientific belief calling to a reconciliation between the two spectrums

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 155–168.

and alluding to a consensual stand to bring these two components together through non traditional schools and creative curricula.

Consequently, it is vital for students in Saudi Arabia while studying science to adhere to an Islamic environment, in order to understand the foundations of ethical and moral concepts as derived from Islam and associated with science. Indeed, the science curriculum has been put in the frontier of a real challenge, which is how to weave science and societal paradigms into one fabric? Based on that, science teacher training programmes need to respond to that contemporary change and assimilate all possible directions that will enable our future teachers to professionally respond to challenges. Pre-service science teachers need to develop a coherent conception of the features of science within a social context to promote the nature of science to students and acknowledge the societal parameters (Nuangchalerm, 2009).

This chapter will consist of a thorough discussion on the ties between science and society as embarked from a moral and ethical awareness standpoint. It is an attempt to present a conceptual framework and scope that couples morals and ethics as they are manifested in science. Therefore, the contributions of different scholars will be given including the early efforts of some Muslim philosophers and the epistemological Islamic base that endorses the ethical/moral system. Deliberate thoughts on science, technology, and society are revealing nowadays; especially as we are drifted towards a secular science. Hence, it is of utmost importance to look at the imposition of science curricula in Saudi Arabia and science teacher preparation programmes and how they correspond to social and technological paradigms while incorporating ethical and moral qualities.

SCIENCE, AND AN ETHICAL AND MORAL PERSPECTIVE

The relationship between science and society is indisputable, as represented in the work of Bruno Latour and recent sociologists, philosophers, and historians of science (Lemke, 2001). Science is not only based on knowledge, rationality, and objectivity, but it is also a social epistemology that concerns social and cultural aspects (Winter & Kosolosky, 2013). The traditional perspective on science as an autonomous approach tied only to knowledge has been contested by research in the history of science, the sociology of science, and ethno-science studies in cultural anthropology and contemporary science studies (Lemke, 2001).

A recent trend increasingly looks at science as a human activity that is very much a part of the social organization and the dominant cultural issues of the present. Eventually, there is an active interaction between science and the principal ethical and moral means scaffold in the society. UNESCO (2005) explains:

> The study of ethics is important not only for our individual lives but also for developing the insight and competence that human beings as a community need in order to face the challenges of the present and the future in a reasonably successful way. Many of the most important ethical predicaments the world

> community is facing today arise in connection with science, in scientific research and in the development and applications of new technologies. (p. 3)

Accordingly, the current revolutionary era in science has raised enormous controversial issues that demand giving more substantial attention to ethical and moral positions; for example, the production of a human embryonic stem cell and genetically modified plants. It has been necessary, therefore, to comprehend science on a socio-cultural ground, whether it is related to the moral and ethical principles in our world or the social skills that are necessary for an active and reactive reasoning for drawing moral judgments (Zeidler, Sadler, Simmons & Howes, 2005).

The investigation of how morals and ethics influence the field of science demands a clear vision of what is considered to be moral or ethical. The two words are widely used as synonyms; however, some distinctions can be outlined. What is ethical or moral is widely denoted with perspective guidelines of action. In many contexts and theories, the word ethics is associated with the rules, regulations and principles of conduct that guide actions of a human cluster or a particular group or a particular culture. In contrast, the word 'morals' articulates personal ideals and principles with respect to conduct. In fact, ethics are fostered in light of external influences, while morals function more intrinsically (Wagner & Simpson, 2009).

Resnik (1998) has also observed a distinction between morals (standards for a behaviour or a social basis to guide a behaviour) and ethics (standards for a profession, institution, or community group). Essentially, what is ethical is not an individual exercise; it is a societal proposition conformed to the definition of right, fair and good, and grounded on the societal legacy of habits, practices, laws and religion (Goldfarb & Pritchard, 2000). Ibn Manthour (reprinted 2007), the author of the famous Arabic lexicon The Arab Tongue, elaborated on this subject back in the twelfth century and considered moral to be descriptive of a human's inner image that in a way is identical to his observable image. From Ibn Manthour's viewpoint, it can be inferred that morals indicate the natural qualities instilled in all humans that have two manifestations: internal psychology and outer behaviour. On the other hand, ethics are the criteria defining individuals' behaviours; they are gained and practised as naturally evolved within a community consensus.

The impact of ethics and morals on science has been widely discussed, and is recognized in several forms. Science is more than a set of knowledge, or a rigorous way of thinking; it is also a set of inner and outer norms tide with the realm of our conduct. The high speed of the scientific and technological revolution has raised numerous debatable issues that strike at our moral and ethical structures, leaving uncertainty for a large number of individuals who must choose between conflicting paths and take a stand on those controversial issues; for example the human oocyte cryopreservation which is a technology that enables a woman freezing her eggs until she be ready to become pregnant. The delay of a mother childhood may be advocated by sociological trends such as pursuing higher education and enter the workforce firmly. Nonetheless, the propagation of such cases may jeopardize the fertility potential, and delay parenthood at normal stages. Clearly, socio-scientific issues possess a typical value-load that acknowledges to qualities of principal norms in our society, and attach to our own lives, as well as the physical and social world around us.

It is evident that society needs applications of science as provided by technology to solve some problems it faces, and maintain human prosperity. However, science has also revolutionised life in the social arena, inflicting a large number of problems humanity. For example, the discovery of the genome mapping could contribute in controlling certain diseases. Yet, the misuse of it would recall Mary Shelley's novel (1818) of Dr Frankenstein who created a monster that turned against him. For this reason, a scientist like Bill Joy has contended that the advancement in science and technology has raised awareness of the profound ethical and moral issues we encounter. Further, he pointed out to the necessity of developing a standard of positive ethical conduct for individuals and societies to direct our quest of knowledge in a constructive manner (Joy, 2000).

SCIENCE AND ISLAMIC CONSIDERATIONS

Formal and empirical strategies should be based on an epistemological ground that is consistent with what is legitimate and discards what is not. However, our judgments are indivisible from the context through which our mindset was structured. In a society in which religion is eminent, a foreground ethical/moral system is situated consistently with the scientific method and consequent rationale illuminated in that religion (Asad, 1986). In Islam, it is encouraged to deliberately recognize the universe through various signs on the horizon, and to think about different kinds of habitats. The assets of the scientific method are in line with the Quran inspirations to observe, induct, and the use of the mind (scientific meditation). The Quran states (Al-ghaashiya, Verse 88:17–20) "Then do they not look at the camels – how they are created? And at the sky – how it is raised? And at the mountains – how they are erected? And at the earth – how it is spread out?" and in another verse, the Quran states (Al-nahl, Verse 16:66) "And indeed, for you in grazing livestock is a lesson. We give you drink from what is in their bellies – between excretion and blood – pure milk, palatable to drinkers."

The Quran has laid out grounds for thinking through scientific consideration and reasoning; it has also forbidden imitation without knowledge, with no mind and no guidance. The Quran calls us to get away from the emotional atmosphere that distracts someone from standing with himself and reflecting. Indeed, that is an overt precaution, to cherish someone's convictions and ideas within a social atmosphere, which may obscure an individual intellectual independence, to go back to a pale shadow of the group. The Quran states (Al-baqarah, Verse 2:170) "And when it is said to them, 'Follow what Allah has revealed,' they say, 'Rather, we will follow that which we found our fathers doing,' even though their fathers understood nothing, nor were they guided."

In science there are many controversial issues that should be projected onto a well defined ethical/moral framework. It is abundantly clear that any further distance from a well rooted ethical/moral reference will lead to contradictory ethical standards or no ethics at all. The doctrine of Islam, as derived from the Quran and Sunnah, promotes the value of a free mind, a mentality with an emphasis on observation, deliberation, and experimentation. Indeed, Islam has identified the great goal of science, which consolidates the spirit of faith in the Almighty God, recognizes the limits of human beings, and acknowledges God's might and blessings on them. However, as Islam calls for the preservation of the universe which is consistent with all doctrines, it also warns against the upholding of materialistic renovation of Earth when it comes to spiritual values and dimensions.

In the Quran, the determination of a sinful act is not always guided by fact, but we are always reminded to be fully aware of it being a sinful act. Humans have the power to know as well as to act and can thus perceive proper and improper actions which will result in an amalgam of rationalism and ethics. Ibn Tufayl, a physician-philosopher in the eleventh century, built on that dichotomy to write his intellectual novel Hayy Ibn Yagthan, which projected the two dimensions of values and rationale and made use of both in terms of the study of the nature and shaping of human behaviour. The ideas of Ibn Tufyal, along with numerous other Muslim scientists, allude to a moral/ethical system that reveals normative provisions of Islamic origins and derives its stability from the Quran and Sunnah to organize acts toward all contemporary issues, including socio-scientific ones (Sardar, 1998).

The forensic matters are projected primarily on the Quran/Sunnah reference; however, Islam has encouraged the formation of an ethical/moral framework that stems from interpretive reasoning, deductive analogy, juristic preference, and consensus interest. Going back to the genome mapping example, some opponents may build their analogy on the menacing of the devil to change God's creation; the Quran states (Al-nisa, Verse 4:119) "And I will mislead them, and I will arouse in them [sinful] desires, and I will command them so they will slit the ears of cattle, and I will command them so they will change the creation of Allah, and whoever takes Satan as an ally instead of Allah has certainly sustained a clear loss." Meanwhile, the proponents of genome mapping claim that it stems from legitimate purposes devoted to the treatment of deformity or disease, or for the production of alternative benefits in organ transplantation.

CONTROVERSIAL SCIENCE ISSUES AND SAUDI SCIENCE CURRICULA

Great emphasis has been placed on the inclusion of controversial issues in science curricula, on the grounds that these will develop scientifically literate and active communities. It is argued that curricula congruent with the socio-theoretical and empirical aspects of science would be particularly useful for students as they confront socio-scientific issues (SSI) (Sadler & Lisa, 2009). Yet, how can the dynamic interaction between nature and society be better incorporated into curricula? For example, taking the genome mapping issue as a paradigm illustrating the perspective of science and society, how genetics knowledge is woven in a curriculum to shed a light on human variability and ability to cure diseases adhering to a social context.

A platform for science, technology, and society (STS) is one key to sustainable development. While an increasing number of educators have asserted that science courses should include the parameters of STS, and foster "the link between SSI and learning science content knowledge as presumed by situativity theory, evidence is mounting to suggest that SSI can, in fact, serve as useful contexts for science learning" (Sadler, Barab & Scott, 2007). In this era, students should be capable of using the skills of and knowledge about science to make personal and social decisions; technology should be an integral component in this process. Evidently, the interaction of the three clusters – science, technology, and society – in related contexts should be the goal of future science curricula.

By the same token, the evolution of a reformed science curriculum should stem from a coherent philosophy that entails both in terms of the study of nature and shaping human behaviour. Al-Isa (2009, as cited in Boujaoude & Dagher, 2009), the ex-president of Al-Yamama university, has speculated on the current situation in Saudi Arabia and asserted the necessity to "adopt a new philosophy of education based on a balance between deep religious, moral and psychological upbringing on the one hand, and possession of mental and behavioural skills that enable [our youth] to become productive and competitive in the future." Congruently, the science initiatives should develop novel approaches to contemporary challenges with individual and collaborative societal preferences, and cognition.

Al Ahmari (2009) remarked that the research studies conducted in the Kingdom of Saudi Arabia to target the evaluation and analysis of curricula in terms of the interdependence among STS at various educational stages achieved mostly unsatisfactory curricula results. All science subjects, in general, were described in terms of facts, concepts, and theories but lacked proper employment of these in the community and the surrounding environment. Our curriculum has been confined to a traditional philosophy favouring the grasp of more knowledge about functional aspects and applications. This dominant view has become an obstacle to curriculum design; an interdisciplinary or integrated curriculum model promoting a different perspective focused on themes and the problems of life experience could be problematic as noted with claims supporting the revelation of information within a content area and precautions of the risk of becoming confused when connected to unrelated subject matter. Therefore, philosophical implications and science objectives need to be revisited and reviewed to reconstruct the conceptual framework of a contemporary science curriculum.

The general objectives of science curricula in the Kingdom of Saudi Arabia as identified and announced by the Commission of Education Policy revolve around the concept of science as a discipline and a faith. They illuminate the vast universe of great and wondrous creation and note the remarkable accuracy in natural objects and events to instil a full allegiance to Almighty God (Almuhesin, 1999). A focal point of these objectives is the link between science and religion. Islam calls for induction, inference, and sound logic to search for truth which is accustomed to scientific impartiality.

The stated goals were written a decade and half ago and lacked relevance to society and life experiences; however, they beautifully identify the goal of basic science as inculcating faith in God. A paradigm that preserves the structure of science as a medium, promotes faith in God, and becomes compatible with the contemporary view of constructive knowledge that stresses the essence of the nature of science through bridging it with social and technological contexts has come to the forefront of the recent science education reform project in Saudi Arabia. New science curricula at all educational levels have been adapted with equal scope applied to faith in God and society in everyday life. Configuring abilities to solve problems and critical thinking in all aspects of learning and enhancing interdisciplinary attempts have been scrutinized in the Saudi modernized science curricula. Creating learning situations that are tailored to encouraging civic responsibility and promoting discourse about socio-scientific issues through a scaffold inquiry are also considered (see Table 1).

SCIENCE TEACHER PREPARATION PROGRAMMES – PRESENT AND FUTURE CHALLENGES

Formal teacher training institutions in Saudi Arabia were launched in 1953. Attendees at these institutions had to complete a three-year programme after finishing elementary school. The programmes primarily aimed to fill the gap met by elementary school teachers; however, many criticisms were aimed at these programmes concerning scientific and educational competencies (Alsalloom, 1995). A series of changes has been implemented over the past 60 years resulting in a 4-year college programme which should be adhered to by all pre-service teachers, or else a higher diploma after a bachelor degree may be obtained in a scientific field. As a matter of fact, all science teacher preparation programmes in Saudi Arabia are adapting either an integrative path or a sequential path.

Saudi universities have crafted their science teacher training programmes according to an integrative structure; for example, the science education program at King Faisal University allocates 60% total credit hours in science and maths courses (45% in a major science field and 15% in a minor science field, usually chemistry paired with biology and physics with maths), while 30% is devoted to educational pedagogical theory and practices, and the remaining 10% is distributed

Table 1. A dimensional analysis for a unit on human reproduction and growth from the 12th grade level (prepared by the Author)

Unit Name:	*Human Reproduction and Growth*		
Content:	General Ideas The reproduction of a human being is a result of the union of a sperm cell with an egg.	Main Ideas Hormones regulate the two human reproductive systems, including the production of gametes. A human grows from a fertilized cell into billions of cells with specialized functions.	Description Informative details about human reproduction and supporting images.
Faith:	In the Holy Quran, God speaks about the stages of man's embryonic development: "We created man from an extract of clay. Then We made him as a drop in a place of settlement, firmly fixed. Then We made the drop into an *alaqah* (leech, suspended thing, and blood clot), then We made the *alaqah* into a *mudghah* (chewed substance)." Quran.		
Life Experience:	Ultrasonic technology uses high-frequency reverberations to create images of the inside of the body. While two-dimensional images are standard, technology is now able to produce three-dimensional images of the foetus, and four-dimensional images or moving images are also available. Consider ultrasound images that display the unknown growth stages of embryos that your teacher provided, and use the timeline set for the growth of the foetus to determine the approximate stages of foetal development.		

Table 1. (Continued)

Unit Name:	*Human Reproduction and Growth*		
Socio-scientific Issue:	Joseph is an 11th grade student. He stopped growing in height two years ago at 157.5cm. His father's height is 190.5cm, while his three brothers' heights are not less than 177.8cm. His mother is concerned for him, because she believes that his height does not allow him to participate in sports, and she suggests that he take a growth hormone to increase his height. The family thinks that this procedure will help him to play sports and improve his life. What do you think about the family's decision?		
Activities:			
Generic Skills	Critical Thinking A woman's menstrual cycle usually begins when a girl reaches about the age of 12 years, and stops at the approximate age of 55 years. What is the number of eggs produced within this timeframe if a girl does not get pregnant (note that the typical duration of a menstrual cycle is 28 days)?	Learn how to Learn Use magazines or online sources to see pictures of growth and ovulation. Study the pictures and comments on the stages of the first ten weeks after fertilization.	
Interdisciplinary	Connection to Chemistry: The role of spermicide Lysosomes organelles with a digestive enzyme is to weaken the plasma membrane of the egg to the extent that it allows a sperm penetration; then the egg is an impregnable barrier that prevents other sperm from penetrating.		Connection to Maths: Draw a growth chart for the first ten weeks after fertilization (see sources provided). Predict the day of delivery as if the egg was fertilized on the 15th of Muharam.

across a variety of general courses. According to the Teachers College Students Guide Handbook, the programme of a general science education specialization is structured from at least 80 total credits in science and an average of an additional 14 specialist credits in the area of their minority (Ministry of Education, 2002). That is, the total will be approximately 94 credits in science out of approximately 147 total programme credits. The remaining 53 credits are divided into 22 credits for general courses and 31 credits for professional education courses. The science teaching programmes at the Saudi teacher colleges show an imbalance credit hours between the theoretical approach and the practical one which obscures the holistic nature of science. Weaknesses in the programme were identified by a series of research studies including Alsharqi's study (2004), which indicated an apparent content appropriateness of professional preparation; however, he also recorded weak contributions of educational and psychological courses to prepare students for the teaching profession.

As of 2007, teacher colleges for both genders were merged with the nearest general educational colleges under the aegis of universities. In addition, many of the integrative science teaching programmes were dramatically shifted to sequential paths, leaving the choice to science college graduates to complete a one-year diploma. This transformation was adopted to consolidate teachers' scientific knowledge base; however, the complementary educational function is debatable. Looking at three higher educational diploma programmes at King Faisal University, Um Alqura University and Taiba University indicates that pre-service teachers are presumably enrolled in a holistic structural programme rather than being tailored to specific fields (see Table 2).

The one-year diploma at the three institutions presumes an adequacy in terms of knowledge of science, and therefore the set-up of the programme is keyed to those knowledgeable in the cultural, societal, and educational spheres. The socio-cultural domain is addressed by two or three courses, which are generally required to be vital for all students with different majors. It is really important to examine if such courses are integral to the science major and do invoke the life experiences in which science and society are involved. In addition, the educational perspective is associated with courses in pedagogy, psychology, and a practicum. The features of a four-year bachelor degree with a sequential one-year diploma model are implicitly or explicitly anchored in the depth of acquired science content and the comprehensiveness of a scientific specialization; however, the thematic and interdisciplinary perspectives of science are less tangible.

Analyzing the results of some previous studies conducted in Saudi Arabia illustrates the inadequacy of teacher preparation programmes in terms of not keeping up with the trends of science topics linked to different sectors of society (Sete, 2001). It could be argued that the strategic challenge facing institutions of teacher training in Saudi Arabia is that of how to transform existing programmes which have been designed according to current needs to be more visionary, in order to prepare for the future. The reconstruction of these programmes should evolve

Table 2. Outline of the one year diploma plan at three higher education Universities in Saudi Arabia

King Faisal University	*Um Alqura University*	*Taiba University*
Students' Counselling and Guidance	Islamic Education Principles	Islamic Education Principles
Curriculum and Teaching Methods	Educational Psychology	Intro. to Educational Psychology
Lessons Design and Development	Intro. to Ed. Administration.	School Management
Education in the Kingdom of Saudi Arabia	The Development of Ed. Ideology	Psychological Health
Educational Measurement and Evaluation	Curriculum Foundations and Designs	Curriculum Foundations
Developmental Psychology	Developmental Psychology	Developmental Psychology
Educational Technologies	Scientific Ed. Sociology	Islamic Educational and Societal Development
Special Teaching Methods	Teaching Methods 1	Computer Curricula in Primary Education
Classroom Management	Teaching Methods 2	Learning and Individual Differences
Educational Psychology	Educational Philosophy	Computer Teaching Methods 1
Computer Applications in Education	Learning Aids	Learning Aids
Practicum	Educational Issues and problems	Computer Teaching Methods 2
	Training on Teaching Situations	Education in the Kingdom of Saudi Arabia
	Tests and Measurements	
	Guiding and Counselling	

from the adoption of strategic planning input, where philosophical and institutional structures are integrated.

Coping with contemporary trends and getting away from the traditional forms of teaching, the Ministry of Education has advanced the launch of the National Professional Standards (NPS) to assist in reconsidering the road map of teaching all disciplines. The NPS encompass theoretical and procedural bases that reflect the integrative and active nature of a contemporary education, as well as the adoption of student-centred education which became the cornerstone of modern international regulations and effective educational bodies. They indicate what teachers should know and do, and thus include knowledge, skills and values that should be met by teachers to do the job professionally and effectively (Professional Standards for Teachers, 2011).

The adoption of the NPS will guide science education in Saudi Arabia and will create the vision of science teachers' preparation in the future. For example, Islamic ethics are taught through different courses in a context that is usually not included in science and technology subjects. It is assumed that students will eventually develop an integrative ethical system that could be projected onwards to various fields and disciplines. New standards promote the nature of science and the dissemination of the ethical skills necessary to integrate new knowledge through the discipline of science within a societal context.

The carrying out of this mission demands capable teachers, and is considered to be both controversial and problematic: controversial because science teachers are considered to hold on to obsolete facts and carry out tasks mainly to disseminate these facts; and problematic because many science teachers lack both the professional scaffolding of ethical issues in the curriculum and the instructional patterns and skills such as a dialectical dialogue among students which have been favourably identified as ways to deal with science subjects relevant to society (Steele, 2012). Accordingly, science teacher preparation programmes should adapt new routes favourably identified to deal with science subjects relevant to society and stressed in the NPS. Thus, the majority of science teacher programmes in Saudi Arabia are expected to be heavily reshaped, and the competencies between the educational institutions will be more consistent based on the capability of such institutions to prepare their students according to contemporary paths and standards. The NPS era has heralded that change is coming, albeit grudgingly and largely at the margins. If educational institutions are not adequately preparing graduates to teach in the new outcome-based NPS and to present-day requirements, they will soon become outdated.

CONCLUSION

Intriguing science and societal implications and relationships has become an inevitably dynamic subject. It comprises different components of society as attributed to ethics and morals and modulate them with the study of science. Fundamentally, the relationship between science and society should evolve from a well grounded philosophy that acknowledges a societal identity and recognizes scientific innovations. In Saudi Arabia, society has a long legacy and is anchored within a profound Islamic ethical and moral system. Accordingly, our science education system should be re-imagined to prepare our students to understand the nature and processes of science, integrated with the ethics and morals that enable them to use scientific knowledge to achieve personal and societal goals.

The successful equation of this re-imagination should be eminent in science curricula through the exhibition of natural phenomena in an arena that integrates science into the technological and social environments of the student. Science curricula should drive students to articulate their everyday experiences within a structure that manifests their personal understandings of their social, technological and natural environments: dealing with a socially driven problem that is germane to science, sensitivity to a dilemma or problem is expected by students and a teacher-facilitated situation raises the social awareness and science intervenes, and the exhibition of students' grasp of science knowledge hinges on instructional strategies that include students' active participation and experimentation.

The implementation of such science curricula involves well-prepared teachers who are in tune with such trends and capable of this transformation. Therefore, teacher preparation and training programmes are an important key to this alteration. These programmes should be mandated to consider the NPS which raise awareness of the profession' s relationship with science and society, and to address the skills necessary to exhibit science's controversial issues confidently. In fact, all these entities should be equally woven into the fabric of the science curricula.

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9. ADOPTING WESTERN MODELS OF LEARNING TO TEACHING SCIENCE AS A MEANS OF OFFERING A BETTER START AT UNIVERSITY?

The Impact of Socio-Cultural Factors: A Case of Bahrain

ABSTRACT

The most recent developments in secondary school science education in Bahrain include adopting inquiry-based curricula. This initiative is part of the government's educational improvement vision which aims at aligning education in Bahrain with other international models and to produce graduates who are able to access higher education in many educational systems. The aim of this chapter is to demonstrate how specific socio-cultural factors may impact successful implementation of such reforms but also to challenge the idea of internationalising schools in the Gulf region as a means of educational improvement. This chapter draws on the findings from a qualitative case study where secondary science teachers, first year university students and relevant university faculty staff were interviewed in focus groups and semi-structured interviews. Data were analysed thematically, using the constant comparative method. The findings highlight the impact of the societal culture on the functioning of schools and the complexity of factors that influence the way schools teach science. They also suggest that the current reform of internationalising science teaching might not be beneficial for future generations of university students. Finally, the research emphasises that socio-cultural factors are difficult to change and that introducing new reforms should be based on considerations of these factors. The chapter proposes that matching reform with the broader societal view on education, rather than trying to change it, might be a more effective way of educational improvement.

INTRODUCTON

Educational improvement has always been at the forefront of education in Bahrain. Continuous efforts have been taken by the Ministry of Education to raise the standard of education in Bahrain and to align the teaching and learning in national schools with other international models. This has been reflected in the implementation of numerous reforms which aimed at providing Bahraini graduates with internationally

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recognised qualifications and at creating better opportunities for accessing higher education (Ministry of Education, 2008).

One of the most significant reforms in this respect included the unification of the specialised track system in secondary education. This initiative was meant to restructure the secondary system in Bahrain according to international models and to give all students the opportunity to study the same courses and practise the same skills, as opposed to the old track system where the emphasis was given either to science, literary or commercial subjects, depending on a student's chosen track. This was believed to enable students access to higher education in the country and abroad because the learning outcomes of the new unified system were intended to be closely aligned with the programmes at the third level (Ministry of Education, 2008). This reform also involved a comprehensive review of the old curriculum in order to reduce the superfluous details of the material that was written locally and to introduce student-centred teaching approaches based on critical thinking and problem solving (ibid).

In science in particular, this review resulted in adopting curricula grounded in scientific inquiry, which were adopted from an American course book series *Glencoe Science*, and translating their content into Arabic so that they could be taught in national schools. Considering that the conventional methods of teaching and learning science, which were characterised by traditional desk-based teaching, still existed in the country's system of education when the unification of the track system was taking place, it was decided that this change would bring about more self-directed pedagogies, promoting learning through inquiry and problem-solving methodology. According to Hameed et al. (2011), these new pedagogies were necessary to develop skills in Bahraini graduates that would raise their competencies to the level of other international students.

However, how these changes in science education have been received by the culture of Bahraini schools has not been researched, which emphasises the importance of the ideas presented in this chapter. A growing body of literature suggests that the success of educational reform or specific pedagogical approaches in new cultures depends on the views of education in these cultures (for example: Jegede & Okebukola, 1989; McMillan, 2005; Dirani, 2006). Mawthoh and Kumar (2011) argue that this is because the socio-cultural influences of a specific nation are realised through the system of education of that nation and they become deeply instilled in the characteristics of its graduates and school pedagogies. Hamdy (2008) who writes about such 'transplantation' of programmes, with their underlying values and contexts of practice, makes a similar point and proposes that adopting programmes from a 'donor' context might often be dependent on the socio-cultural context of the recipient culture, specifically when strong cultural influences of the country are concerned.

Bahgat (1999) points out that the Arab curriculum and school practices can be difficult to change because they derive from very strong societal beliefs about what good education should involve. Al-Sulaiti (2002) writes that since the inception of education in Bahrain, the emphasis of schools was on the mastery of certain subjects to respond as quickly as possible to the growing demand for literate people who could teach and work in offices. This had led to the growth of memory-based pedagogies which allowed the students to acquire large amount of knowledge without making many mistakes, and that is why, even nowadays, enabling the students to acquire large amounts of knowledge with minimal mistakes is seen by the wider society as the best education (ibid).

Additionally, societal beliefs about the influences of the teacher substituting for the father outside the family circle and the school being an institution that teaches discipline and obedience had led to the creation of the education system that insisted on dependence and compliance with the family and society's moral code (Qaddummi, 1995). This reinforced the teaching method that favours the authoritarian role of the teacher, rote learning and inculcation.

> Such method is, in fact, made to strengthen the teacher's power and to ensure the subjugation of the students to his power. It emphasizes memory related activities which would eventually lead to assist the training that the child had received in the family when his mental development was directed towards speech competency rather than questioning and investigation. (Qaddummi, 1995, p. 317)

According to Shirawi (1989), such beliefs about education fossilised teacher dependency, the focus on rote learning and the need to do well in exams but, at the same time, Shirawi (1989) claims that these methods seem to suit the citizens of Bahrain. Through researching education in Bahrain, I began to develop an understanding that, operating within a set of such inherited beliefs and traditions, Bahraini students expect that learning is confined to memorising sets of prescribed materials which prepare the students to pass examinations. This gave rise to my doubts about the value of internationalising the secondary school curriculum and indicated that it cannot be easy for policy makers to fully implement the new American series that are based on completely different principles. The impetus for changing the science curriculum was to shift the inherent views on education following the need for graduating citizens who learn in the same way as students in the West. However, how this was going to be received by the culture that had not learnt in this way before had not been fully considered. I felt that evaluating foreign policy after 'transplanting' it to the local culture was important, which resulted in my interest in researching the context of science education in Bahrain. Such focus on research was also one of the implications resulting from my earlier work on the role of science education in the transition of Bahraini students to a Western medical university. Below, I will present a short note on the context of this university as the findings from the lecturers who work there are discussed later in the chapter.

The Context of the University

The university were the lecturers were interviewed adopts the same programme as the parent campus in Ireland, with its values and structures. The undergraduate programme is based on an outcomes-based model which is primarily lecture-based in the early years and supplemented by a number of tutorial and laboratory sessions. The assessment policy is based on the measurement of stated learning outcomes which is achieved through high stake end-of-semester summative examinations.

The rationale for interviewing faculty members at the university was that such a specifically defined HE programme may pose some obstacles to students who transition from culturally different learning environments. Particularly, the concern was that students who were educated in science in Arabic may suffer from having to learn in a foreign language because they will be expected to acquire large amounts of material from high-content didactic lectures and to interact in tutorials (Jin, 2011). Another concern was that they might also suffer from inadequate conceptions of learning for higher education arising from the socio-cultural framework of their pre-university education (Bhattacharyya, 2010).

Considering these concerns, my research on transition from the Bahraini context to Western higher education (Hayes, 2013) was grounded in the socio-cultural theory which proposes that learning is organised by an understanding of concepts developed in the context in which individuals interact (Vygotsky, 1978). From this perspective, learning science was seen as one of these concepts and, therefore, the ways in which students respond to and engage with science education at the medical university was thought to be subject to the cultural and social influences of the country. In order to explore these influences, I interviewed science teachers at secondary level and 1st year university students from Bahrain, which also shed some light on the doubts I had about the value of changes in the science curriculum in Bahraini schools. My research on transition also involved interviewing university lecturers who were able to discuss the impact of science education and the socio-cultural framework of students on the university careers of fresh Bahraini graduates. Through interviewing secondary teachers, students and university lecturers, I was able to develop a chain of evidence and strengthen my interpretation of the data presented here, ensuring greater validity and confidence in the findings (Andrade, 2009).

The perspectives of science teachers, students and university lecturers are presented in this chapter for two reasons. Firstly, the voices of secondary teachers and students give us an insight into how strongly cultural and societal views on education and the socio-cultural context of Bahraini schools can impact the successful implementation of the new inquiry-based science curriculum. Secondly, the perspectives of university lecturers suggest that this implementation might not be necessary to improve science education and to give students a better start in higher education, as was foregrounded earlier in this introduction. These will hopefully provide some food for thought for considerations of whether Western means better and whether internationalisation of programmes in schools outside the Western context leads to educational improvement.

THE IMPACT OF SOCIO-CULTURAL CONTEXT ON THE SUCCESS OF EDUCATIONAL REFORM: PERSPECTIVES OF SCIENCE TEACHERS

Under this section of this chapter, I would like to present data obtained from 22 secondary science teachers who were interviewed in four separate focus group sessions in four different national schools in Bahrain. These schools were randomly chosen from each governorate in Bahrain (n=5) and the interviews stopped when data saturation was achieved. The aim of these interviews was to explore how the Bahraini context of schools influences teaching science and whether this context prepares students well for higher education. The interview questions, therefore, were designed to discuss the latest pedagogical approaches (e.g. How much independent learning takes place in science?), science content (e.g. Is teaching science integrated? How does this affect the students in terms of their application of science?) and any influences, at the school and cultural level, which may impact the way science is taught (e.g. What guides teaching science in Bahraini schools? Are there any things at the school/cultural level that affect the way you teach?). The interviews lasted on average 60 minutes. The interviews were conducted in English and Arabic and they were transcribed in full. The part that was conducted in Arabic was simultaneously translated by an Arabic speaking teacher of English for the interviewer to respond to the dynamics of the interview and the Arabic transcripts were subsequently back-translated by research assistants and sent to participants for respondent validation. The constant comparative method was used in data analysis (Glaser, 1965).

I would like to use the perspectives of science teachers in this chapter to argue that socio-cultural factors may impact successful implementation of educational reform. The major themes that were derived from the interviews include inadequacy of reform for the context of Bahrain, the impact of the value that is given to memorisation and the role of the general view on education in implementing foreign curricula. These themes seem to support what is proposed by, for example, Hallinger and Leithwood (1996) who state that what is happening in schools depends on the broader societal culture of communities and that schools have to adapt to what the society believes should be the goals of education. The teachers interviewed in my research demonstrated this very clearly by explaining that full implementation of Western models of teaching science is unlikely to take place because the teachers, the students and the parents, who have all been influenced by the societal view on education, are not ready to accept that learning can involve something different than memorising information from course books.

Every teacher admitted that despite the official implementation of the American series for teaching science in secondary schools in Bahrain, the methods of teaching have not changed and that classroom pedagogy is still based on memorizing theoretical information:

> *Teacher 1B:* The curriculum is the same as in the American state [sic] but the difference is in the method of learning. Yes, that the only difference, yes […] Same same but the difference is in the teaching, the teaching depend on the data in the book only, not the lab and the students doing experiments in the lab, no.

This focus on memorizing theoretical information from course books, according to all the teachers, makes it impossible to fully implement the inquiry-based curricula and *this is the problem with this curriculum that we have now (Teacher 2B).* The teachers stated that implementing the inquiry-based curriculum requires building a new understanding of what learning involves but this is hard to achieve in Bahraini schools because *we don't practise that with them (Teacher 3A).*

One teacher explained that to teach through the American series, students must be *proficient of physics rules and their deriving, student must understand how change from this law to another law and understand how he can use the results (Teacher 2C),* instead of learning only through memorisation. However, learning through memorisation was seen by all teachers as unavoidable because of several socio-cultural aspects of education in Bahrain.

One of these aspects was, in the teachers' opinion, related to the socially constructed value of memorisation. The interviewees revealed that the emphasis on memorisation is so strong because it is culturally ingrained in the minds of parents, students and teachers themselves when they were in school. Building knowledge through memorisation was the only way they knew and the interview comments suggested that teachers will continue to teach in this way, despite the attempts to try to change the pedagogy to a more critical thinking approach:

> *Teacher1D*: This is the way we brought to teach [sic], this is the way how we study, this is the way we teach, this is the way how we pass and this is the way we are going to teach.

All teachers agreed that because of this cultural importance of memorisation, the value of critical thinking that characterises Western models of teaching is diminished in Bahraini schools. This is also why teachers do not know how to teach via critical thinking approaches and they continue to use styles based on memorisation:

> *Teacher3D*: The teacher is not even qualified to the meaning of critical thinking and how to use it. It's rarely to use critical thinking, I mean the teachers who use critical thinking are very few. The teachers are not using it, the teacher is only teaching the memorization and that's it.

The interviewees additionally reported that due to the traditional view on education that promotes obedience and rigour, memorisation is the best approach and that it is impossible to teach differently in Bahraini schools because if teachers start implementing critical thinking approaches *this will make it worse because to entertain the students while they have to study and take things seriously, this will make a lazy generation who wants to get entertained in everything (Teacher 1D).*

The interviewees finally agreed that, culturally, students and parents place a lot of value on final marks, which is why they prefer styles based on memorisation. These can guarantee high scores and *they will be happier if it is easy to have percentage of 99.9 (Teacher 2B).* If the teachers, on the other hand, start implementing assessment based on critical thinking, the students' marks might drop because assessment will require more than pure reiteration of knowledge and *the fathers and mothers make problems if their children don't do well in the exams (Teacher 2B)*:

> Teacher 2A: There are people, they maybe if her son lose half degree, they make for you a big problem and they will go to the manager. 'This is not a good teacher', they will say.

These last points in relation to memorisation and the emphasis on final marks suggested another socio-cultural aspect of the school context in Bahrain that might prevent the change in science education towards more Western models. This includes the great importance that is given to national exams and the general societal view that the goal of education should be focused on preparing students for these exams. This great value placed on these exams also seems to explain the emphasis on the acquisition of theoretical information discussed above because all teachers acknowledged that the view on education in Bahrain is that schools should prepare for the final exam, which concentrates all teaching *on the data from the book only (Teacher 4B).* The teachers also agreed that due to the focus on the final exam, they are required to cover the curriculum in full and that implementing critical thinking approaches would not leave enough time to do it:

> *Teacher3D*: The time is not enough to waste the lecture for that [critical thinking], because the course will not finish this way. The second thing is it is not included in the exam; there is only the theoretical part.

The teachers also seem to believe that Western models of teaching are unlikely to be implemented in Bahraini schools because, due to the emphasis on theory in the final exam, students want to focus only on the theoretical part and they feel that *the most important for them is to have a teacher who can explain and summarise for them, never mind the critical thinking strategies (Teacher 3D).*

This focus on the final exams leads, in the view of all teachers, to adopting specific spoon-feeding pedagogies that require the teachers to provide model answers. This again is contradictory to Western approaches that promote learner independence and self-efficacy but *all Bahraini students study only for exams (Teacher 2A)* and *they want only a ready teacher to summarise for them and teach them. The good teacher is the one who is going to give them, spoon-feed them, make it easier, simplify the subject (Teacher 2D).*

> *Teacher3D*: We do it for the purpose of exam, but what we can do? It must be like this. We write everything on the board and teach them the answer.

Such spoon-feeding, in the view of all teachers, hinders the full implementation of the inquiry-based curriculum, which is viewed by the teachers as promoting independence and autonomy, because schools do not focus on developing learning identities that enable students to gain and organise study information independently. The teachers stated that Bahraini schools are different from Western schools in that they provide the students with a complete set of study notes:

> *Teacher2A*: No, it's totally different, here we are almost giving them everything… It's in all the subjects not [only] in the science… We give them everything. Like a box, Bahraini students [are] like a box, you give him information they after can open this box and all the information inside. This is Bahraini schools.

The focus on the national exams was also reported to prevent the teachers from teaching professional scientific terminology in English because only terminology in Arabic is tested in the final exam. And even though it might not be directly related to the success of Western programmes in Bahraini schools, because it cannot be expected that national schools in Bahrain will teach their curriculum through the medium of English, it is important for what I will try to argue later in this chapter regarding Westernising national programmes in Bahrain as a means of educational improvement.

I have mentioned earlier in this chapter that the data from the science teachers were collected as part of my research which focused on the transition from Bahraini schools to a Western medical university. While considering factors affecting this transition, all teachers agreed that *studying in Arabic and then in English is a factor in transition (Teacher 4C)* and reported that even though science course books in Bahraini schools feature sections on medical terminology in Arabic and English, students are not interested in learning the terminology in English because only the terminology in Arabic is tested in the final exams:

> *Teacher 4C:* Because in the exam it doesn't depend on the English terminologies so students don't pay attention to it, so this is the problem that faces us; if the terminologies are not included so the students don't care about it, and this is a problem.

In this way, the teachers once again pointed out that the general societal view on education has a greater impact on what is taught than what is required to be taught and they agreed that it would be easier to teach medical terminology in English if the broader view on education in Bahraini schools did not place so much emphasis on the final exam. By stating this, the teachers suggested that even such a small attempt at internalising education in Bahrain with Western programmes as teaching some professional vocabulary in English cannot be realised because of the strong influence of societal factors on the internal practices of schools.

The findings presented above support what I am trying to argue in this chapter about the powerful role of socio-cultural factors on the successful implementation of educational reform. On the other hand, despite the fact that the teachers believe that adopting Western curricula and their successful implementation might be obstructed by the socio-cultural context of education in Bahrain, they, at the same time, think that the level of science education in the Kingdom is very high and that changing the curriculum to the American one will not lead to educational improvement because *the science material in Bahrain is much stronger than the material which applied in other Gulf States (Teacher 1B)*. This seems to support the 2008 rankings from the Trends in International Mathematics and Science Study (TIMSS) which placed Bahrain in the twenty-sixth place in science, moving from thirty-third in 2003. Bahrain also secured the leading position among all five Gulf Cooperation Council (GCC) countries (Bahrain News Agency, 2008).

In the introduction to this chapter, I pointed out that one of the driving forces behind the change in the science curriculum is that this new curriculum movement is believed to create greater opportunities for students to enter universities in Bahrain and abroad. The teachers whom I interviewed, however, seem to think that this leads to poorer science education because the methods based on critical thinking that are proposed by the new curriculum cannot be implemented for the reasons outlined above but also because the knowledge base contained in the new programme is poorer than in the old courses. This, in their opinion, can lead to greater difficulties with learning when students enter university. All teachers felt that the old science curriculum provided a good foundation for science students beginning higher education because *their level is similar to university level (Teacher3D)* but the new programme is written *in brief summary and the human systems are in brief summary* (*Teacher 3D*). Now, *there is one paragraph in the book replacing a whole module we taught before (Teacher 3A).* Also:

> *Teacher 2A*: Now, we have only the general and the main idea not coming into the deep. [In the past] it takes everything, when we were talking about the skin, it's go deep. In the past we have everything in this, but now no. Before, we take the books, every book is for something, for specific course, material, organic, unorganic also, now the name of the book is general physics one, physics two, there is no optic physics.

Similarly to Teacher 2A who pointed out the lack of optics in the physics programme, other teachers also remarked that some essential areas of science are not included in the current curriculum, which might negatively affect students' learning at university because *before it was a course for organic chemistry, but now not there (Teacher2D)*. In biology, for example, *there is some weakness in molecular biology, hydrogenic* [sic] *and modern sciences related to genes and studying the cells. There is a gap (Teacher 5B).* So, the teachers were concerned that with the removal of courses, for example in organic chemistry or some aspects of biology, the students would enter higher education with poor background knowledge and the transition of Bahraini students might be more difficult because *when they go to the university, they are shocked of the level there, it's too hard for them (Teacher 2D)*.

In the next section I would like to focus on the perspectives of 1st year university students who, along with the science teachers, were also interviewed during my research focusing on the transition of Bahraini students to the first year of study at a Western medical university. These students were selected purposively and comprised all Bahraini graduates from the country's national schools. The students who took part in the study were all Bahraini, they completed state education and they all studied science in Arabic. They were also all enrolled in the medical programme. Two rounds of focus groups were conducted with these students, each lasting on average 60 minutes. Four groups of students were interviewed in the first round (n=10, n=12, n=7, n=6) and 9 students from the initial groups decided to take part in the second round. The focus groups were conducted in English and they were audio recorded. The interviews were transcribed in full and the data were analysed using the constant comparative method (Glaser, 1965).

The perspectives of the students support the views of secondary teachers regarding the suitability of old programmes for higher education. These students were educated through the old 'local' curriculum and graduated from secondary level before the change in the science curriculum took place. I would like to use their perspectives to argue the second major point in this chapter, namely, that Western does not always mean better and to suggest that, contrary to the popular view, students from non-Western schools who follow national curricula might be as well off in Western higher education as students educated in Western systems.

HOW DO STUDENTS FEEL ABOUT THEIR 'LOCAL' SCIENCE EDUCATION AND ITS ROLE IN THEIR TRANSITION TO A WESTERN UNIVERSITY?

The teachers whose perspectives were presented in the previous section felt that the great emphasis on the final exam in Bahraini schools makes Bahraini students less successful at tertiary level because it prevents the teachers from teaching medical terminology in English. Similarly, all students who were interviewed in my research on their transition to a Western medical university agreed that this aspect of their socio-cultural framework played a role in their transition and they emphasised that science subjects in government schools should be taught in English because when *they [*students*] graduate, they don't need Arabic skills (ELC2 Student 4) but at university it helps, it makes shorter the time of study (Non-ELC1 Student 2).*

At the same time, the students in the study revealed that their transition to the university was not threatened because the good science knowledge that they brought with them from school helped them overcome the initial difficulties connected with the lack of medical terminology in English. The responses collected in relation to subject knowledge revealed that all medical students regard this area as their strong point. The students reported that because *the science at school was so strong (Non-ELC2 Student 1),* it enhanced their understanding of the lecture content and helped them overcome language barriers because *the basics of science, we have it* *from school and we are just relearning it now in English (Non-ELC1 Student 5)*. All students reported no difficulties with moving through the learning outcomes of the Foundation Year (FY) programme and expressed great confidence in their background knowledge:

> *Non-ELC1 Student 3*: What was easy was that all the material that we are taking now, we have taken in government schools, maybe even in deeper ways, not in a way we are now, so that's why it was very helpful. Because we know what they are talking about, we understand the whole subject.

These findings suggested something very important. Similarly to science teachers who felt that the old programmes provided students with a good science base and prepared students well for university, the students also implied that the old programmes enabled their participation in higher education. This seems to provide some basis for reconsiderations of adopting Western programmes 'just because' they are Western and for rethinking the assumptions that if local programmes are changed into international ones, students have better chances of succeeding at university. The perspectives of students presented above suggested that students who studied locally designed courses can be as well off in higher education as their international peers because these programmes provided them with sufficient science knowledge that helped them overcome difficulties connected, for example, with studying in a foreign language. If they had followed the new American series, there is a possibility, based on what the science teachers reported earlier, that they would have entered higher education with poorer background knowledge and no critical thinking skills, whereas now, they can at least use their background knowledge. In fact, more findings from the students also suggested that critical thinking skills were not necessary to make the transition, which highlights the need for discussion of whether Western means better.

The perspectives of teachers presented earlier indicated that acquiring knowledge in science in school was based on memorising teacher notes and texts from course books. It seems that the students who were interviewed in my research also managed to transfer these study strategies to the context of the medical university because *some of the subjects you need to memorise, like anatomy, there are books and you need to memorise (ELC2 Student1)* and *there are certain subjects, like in physical development, they never change, they are concepts, you have to memorise it (ELC2 Student 4).*

The students' transition was therefore not threatened by the lack of critical thinking skills because, as they all stated, they felt that the memorisation techniques they used to study science in school supported their learning because *of course that we need to understand the lectures, but it is, I think like 60% to memorise (ELC1 Student 3).* So, knowing that they could rely on memorisation gave the students confidence that they were suitable for higher education and seems to have created a sense of security:

ELC2 Student 2: I think memorising is a backup for understanding. When you understand something and when you like memorise it, you feel confident. Even when you go in the exam and you forgot the things you understood, at least you memorised it.

The findings that follow in the next section expand on the ideas presented here and provide more food for thought in terms of Westernising science programmes in the Gulf as a means of educational improvement and creating better opportunities for entering higher education. Below, I would like to focus on the perspectives of the university lecturers regarding some issues related to the context in which science in Bahrain is taught and how this affects the transition of local students to Western medical education to provide some more evidence for considerations of whether Western means better. Using purposive sampling, the whole population of lecturers who deliver the programme in the 1st year were the students whose perspectives were presented above study was interviewed. Each lecturer was interviewed individually in semi-structured interviews which lasted about 60 minutes. The interviews were transcribed in full and data was analysed using the constant comparative method (Glaser, 1965).

VIEWS OF UNIVERSITY LECTURERS REGARDING THE VALUE OF SCIENCE EDUCATION IN BAHRAIN FOR HIGHER EDUCATION

I interviewed the 1st year faculty at the medical university, who teach the students whose perspectives were presented in the previous section; with regards to the transition of local students in Bahrain to tertiary level education, all lecturers stated that beginning higher education might be difficult for students as learning the curriculum at university may pose additional demands on students, related to the depth of the material. The faculty did not think that *they've [students] taken it into consideration what they learn here and I think it's a large step in what they have learnt before, what they learnt in biology and where the curriculum is based (Faculty 4)*. With regards to local students, the faculty agreed that the change of language might be an additional problem because *if the English language is poor, their ability to absorb the information is very compromised (Faculty2)*. They also acknowledged that having to simultaneously bring one's level of English up and learn the subject information must be difficult for the students and that this might result in poorer transition in terms of moving through the learning outcomes:

Faculty5: They are thrown into the deep end, so probably before they even have an English class, they have a physics lecture or chemistry lecture and so on, so their English language level or skills are not there to allow them to learn normally the other subjects, so they are basically on a losing track at a very start and this can serve to demotivate them.

At the same time, all lecturers were in agreement that *we've seen, we've done a lot of stats on it and we've seen the students that come from the national system will soon be as well off as those coming from the international system and in general their marks tend to be higher (Faculty 4).* They also agreed that the students who seem to have made the transition almost seamlessly are those students who are able to apply the knowledge from school to the university context. The lecturers' view was that Bahraini students *worked out their way of doing that and what they are doing is translating English into Arabic and back, some of the materials that we do with them is what they studied in their Arabic curriculum and they are able to transfer some of that knowledge across (Faculty 5).*

These findings support the earlier perspectives of science teachers and students presented in this chapter regarding the great value of science background knowledge offered by local curricula in Bahrain for higher education, suggesting, at the same time, that replacing them with the American series is not necessary to create opportunities for a better start at university.

All lecturers were in agreement that transferring this knowledge is possible because it seems that what made the students high achievers in school also makes them high achievers at university, therefore, additionally suggesting that it does not necessarily mean that if schools follow critical thinking approaches, as opposed to rote-based pedagogies, their graduates will be more successful at university. One faculty member highlighted this in the following way:

> *Faculty2*: When I look at the list of high achievers I rank them based on the raw results, there are plenty of high achievers who've come to us with scholarships from Tawjihiya[1] for instance, who are high achievers as well. They have been able to make that transition almost seamlessly and I often ask them and it seems that what has worked for them in secondary school also works for them here. Obviously they are making some adaptations but they seem to have all the tools that are required to remain high achievers here.

This supports students' earlier points about the transfer of study strategies from school to university. The lecturers agreed that the high achievers at university have a great ability to recall and that the adequacy of memorisation as a learning technique builds up levels of comprehension required by the medical university:

> *Faculty2*: When I ask the high achievers 'How do you do it?' they very quickly tell me they've just learnt the material. I think that the high achievers have cracked how they personally learn and they are able to do it. And in most cases they just go through every piece of information we give them and they learn it, whether it's by rote learning I don't know, I think that their comprehension issues goes hand in hand with it, they automatically comprehend because they absorb a lot of information, it's already there.

That is why the faculty think that Bahraini students who have been taught to acquire knowledge by rote can be very successful university students. The faculty also acknowledged that a lot depends on memorisation in most of the modules in the first year of university, which maximises the chances of transferring learning strategies from school to third level. For example, Faculty 4 explained that memorisation is dominant because the majority of the material requires the students to label diagrams and remember the steps of life cycles:

> *Faculty4*: [It] requires a lot of memorisation and you will see a lot of the questions that require them to label the diagram, so they are required to memorise the labels of the diagram… You take them through the steps but again they have to learn the steps, you should know the first step, you should know the second step, some of them are taught in cycles, some of them it's just a repeated thing. They don't really have to figure it out for themselves. You just tell them how it works and they are happy enough to learn it.

Faculty 2 agreed with this view and explained that eliminating memorisation would be impossible because of the specific nature of some subjects that require an extensive knowledge of diagrams. Faculty 2 also added that this nature of programmes facilitates the transition of students with lower English proficiency and makes the role of language less important:

> *Faculty2:* We try and avoid it, but it is unavoidable, particularly if you present a diagram and you ask them to label that diagram. You do have to learn the diagram. There are quite a few questions like that and the reason we moved over to that is because we're in an international university, you have various levels of English and therefore [have] to get the information from the students with a minimum amount of written English.

What is important for the focus of this chapter is that the findings from the lecturers once more suggest that for students to be successful at a Western university, they do not necessarily have to study in schools that follow Western programmes.

Overall, the data presented above have shown that societal culture has an impact on the functioning of schools and revealed the complexity of factors that influence the way in which schools teach science. It has also been shown that the role of science taught through the national curriculum in Bahrain in making the transition to a Western university is very positive, suggesting that the current reform of implementing foreign curricula might not be beneficial for the university careers of future students. Finally, the data here have also shown that socio-cultural factors might be difficult to change and suggested that educational improvement should be based on considerations of these factors. This opens up a discussion of whether adopting Western programmes can solve problems with rote learning in GCC countries and proposes that matching reform with the societal view on education might be a better way forward. I will address some of these issues in the closing section of this chapter.

DISCUSSION AND IMPLICATIONS

The Power of Socio-Cultural Factors and Their Impact on Successful Implementation of Reform

Rogus (1985) describes societal factors as one of the main barriers to successful education. The author claims that 'schools reflect rather than determine the values of society' (p. 172). It is also possible that this is why some authors wonder about the success of the internationalisation of education and link this success to students' socio-cultural framework (Hirshy & Wilson, 2002; Serpell, 2007; Bhattacharyya, 2010). For instance, Hamdy (2008), who writes particularly about medical education, calls for research that would explore how Western medical programmes are received by the specific framework of Arab cultures. And while the focus of Hamdy's (2008) work lies mainly in higher education, his thoughts regarding the impact of the culture in the Middle East on the success of Western education in Arab countries were found to be very relevant to the content of this chapter. Hamdy (2008) writes about the role of views on education in the specific Middle Eastern context in the transplantation of medical education based on Western models. He argues that the success of these medical programmes might depend on the differences between Western and Arab contexts and concludes that transplanting programmes from what he calls 'the donor institution' to the recipient culture with its specific values, beliefs and contexts of practice may have specific implications for educational reform.

The data presented in this chapter have led to similar conclusions and the findings from the science teachers in particular implied that interactions between the cultural norms of the Bahraini context and the types of educational programmes that are imposed on schools may impact the success of improvement reforms and affect administrative efforts to align science education in Bahrain with Western models. This supports what is argued about the power of socio-cultural contexts by, for instance, Hallinger and Leithwood (1996) who claim that administrative decisions act as an independent variable affecting the community of teachers, students and their parents. This means that what happens with a particular decision is impacted by what the teachers and students want (ibid). Consequently, what it might mean for the latest reform in secondary science education in Bahrain is that programmes based on inquiry-based models are not likely to be successful in the Bahraini context because the negative reaction from students, teachers and parents reinforces the traditional approach to science teaching which matches the desired educational ends of achieving high marks on the final exams. This points to the very powerful impact of socio-cultural factors on the development of reform because it has been shown above that these factors reinforce rote methodology in Bahraini schools that, as explained by the teachers, prepares students for the final exam rather than the university. This is not what was intended by the Ministry of Education, which shows that the ways schools operate are more likely to be influenced by what society feels should be the goal of education, rather than what administration perceives to be the ideal educational model.

However, while the data presented in this chapter suggest that socio-cultural factors are difficult to change, they also generate some practical implications which suggest that matching reform with the broader view on education, as opposed replacing the existing models with foreign ones, might be a better way towards educational improvement. For example, the important findings in terms of practical implications that were presented here were that implementing Western models in national schools is restricted by the general view on education in the Bahraini society and by the great value of the final exams. It was suggested that this shifts the pedagogical practice of teachers from the expectations of the government and, despite many reforms, results in learning based on rote and memorisation. The practical implications that arise from this are that perhaps instead of trying to completely change what is happening in schools, by moving from traditional to Western approaches, which were reported in this chapter not to suit the culture of schools, this could be done gradually by slowly matching these approaches with a specific local context.

Bax (2006) writes about considering socio-cultural contexts before implementing new educational approaches, using an example of Communicative Language Teaching (CLT) as a new approach but whose general ideas could be applied to the context of science as well. He proposes that if some problems with educational reform occur due to resistance from the local context, local adaptations of this reform should be seen as equally valid. This could lead to the development of courses that contain elements of the new curriculum but yet retain the core principles of the original programmes (ibid). This, according to Bax (2006), could also result in better reception of reforms, which in this chapter was reported to be a big problem.

For example, the science teachers whose perspectives were presented earlier acknowledged that Bahraini parents and teachers do not see the value of critical thinking approaches because this is not how they used to be taught and they feel that this does not prepare students for the final exams. Consequently, instead of perhaps drastically changing the approach, the Ministry of Education could think of ways of introducing critical thinking elements into the current teacher-centred and text-book based approaches which would still allow the students to memorise some texts but could also graduate better university students by making them solve a certain number of tasks based on problem solving. This could, for example, be achieved by changing the format of the final exam, which would eradicate some problems with memorising the model answers, but without trying to change the views of parents that education should focus on something different than the final exams.

As demonstrated in the findings, at present, the emphasis of teaching is still on theoretical information because it can be memorised, which in turn guarantees high marks. As a result, learning is also expected to be simplified by teachers supplementing all study notes. This creates a tension between the objectives of the new curriculum and the assessment of this curriculum. If this gap is addressed, the tension between the socio-cultural expectations of education and the new policy will also be reduced because teachers will still be expected to prepare students for the new assessment but their methods will have to be changed. Changing the deeply ingrained values that schools should prepare students for assessment because good marks are equal to competency and accuracy (Shirawi, 1989) could be difficult. At the same time, aligning the assessment with the outcomes of the new curriculum could be a lot easier, without 'violating' what the society thinks good education should be, which seems to be one of the problems with internationalisation policy (Abdulmajeed, 1995).

While proposing more solutions is beyond the focus of this chapter, it should also be considered that making these adaptations might not be necessary at all. The data from the students and university lecturers suggested that the science education Bahraini students had received before the change in the curriculum was sufficiently good to enable them access to higher education. These data give grounds for questioning whether Western does really mean better and I make some remarks related to this question in the closing section of this chapter which suggest future work in this area.

So, Does Western Mean Better?

I am aware that the findings in this chapter are only derived from a case study and that more work is needed researching similar issues with a greater number of samples to be able to make more robust conclusions in terms of internationalising 'local' programmes as a means of educational improvement. However, they provide some evidence for debating whether adopting Western models is necessary to improve science education in Bahrain, and perhaps in other similar contexts, specifically in terms of students' participation in higher education.

The data cited earlier in this chapter suggest that both students and university lecturers regard the science base taught in the old programmes as students' strong point. The science teachers also revealed that the science content in the old programmes was covered in more depth and their comments suggested that with the introduction of the new programmes, the coverage of topics essential for university becomes very superficial and that in fact some essential areas of science have been removed from the new programme. This, in the teachers' view, will pose threats to Bahraini graduates' higher education careers because they will enter university with poor subject-specific knowledge.

Subject-specific knowledge has been noted in the literature as an important factor in transitions (for example: Chen & Donin, 1997; Wang et al., 2010). Specifically, when English learners are concerned, as it is the case here, this subject-specific knowledge has been found to enable students to overcome language difficulties because language becomes dominant only when the content taught in lectures is unfamiliar to students (Cummins, 1981). The students and the lecturers in my research stated very clearly that Bahraini graduates are able to strategically transfer what they learnt in the Arabic curriculum to compensate for the lack of English.

This supports Cummin's (1981) claims that students who are well educated in their disciplinary areas in their native language, are able to overcome difficulties with the academic language proficiency more easily.

It is therefore suggested here that policy makers should consider whether introducing foreign science programmes is worthwhile and whether removing strong aspects of the old programmes, which in this case was subject-specific knowledge, from the students' capita in favour of implementing inquiry-based curricula will actually ensure graduates' better participation in higher education. The science teachers in this study suggested that critical thinking and problem solving approaches that could help with study at tertiary level cannot be implemented due to the socio-cultural context. Thus, it seems that removing this element of strong subject-specific knowledge may have even more negative consequences for students' success at tertiary level.

The data in this chapter provide even more food for thought in that they imply that not every university requires higher thinking skills in the initial stages of study. This should also prompt policy makers to rethink their decisions about implementing problem-based approaches because it has been clearly implied in this chapter that this is not necessary for a better access to higher education. Both the faculty at the university and the students agreed that strategies based on memorisation could be transferred to the context of the university and that student strategies acquired in schools also worked for them at tertiary level. More work is therefore required in the local contexts of schools and universities in the GCC region and beyond, for it has been shown here that, for instance, in outcomes-based university programmes, which was the context for my research, memorisation-based approaches are equally valuable. This might not be the case, however, in institutions following different models. In fact, implementing Western programmes only because they tend to be based more on critical thinking could be more harmful for students who wish to continue into higher education, based on what Torenbeek et al. (2011) propose about the continuity of study approaches from school to university.

Torenbeek et al. (2011) argue that if learning conceptions about how the subject can be mastered are continued from school to university, transition to higher education is facilitated. On the other hand, if the course at the university starts off as 'too academic' or if the school pedagogies are perceived to be more demanding than the university's, this transition might be negatively affected. Torenbeek et al's (2011) conclusions are in good agreement with the experiences of the transition of the students presented in this chapter, who reported fewer problems with learning in their first year because they were able to transfer the learning strategies from school to university. In the view of the students and the university lecturers, the course in the university did not start off 'too academic', which resulted in better participation of Bahraini students in higher education and which provides more reasons for researching whether Western means better.

While a lot of literature suggests that students whose education was based on memorisation face difficulties in Western contexts (for example: Bhattacharyya, 2010; Jin, 2011; Yang, 2011), the students and the university faculty in this research acknowledged that memorisation helped them with comprehension of science required at university level. Tan (2011) proposes that when memorisation is considered as a culturally embedded construct, it is believed to lead to a deeper understanding of concepts because it is underpinned by deep cultural values. In other words, when memorisation is perceived by a nation as working hard, it becomes something more than rote learning and the cognitive process of memorising becomes more intricate. That is why it is often used to enhance learning (ibid).The findings presented in this chapter, as well as some ideas presented in the introduction section (for example: Shirawi, 1987 or Al-Sulaiti, 2002), suggest that in Bahrain memorisation is a learning approach that was developed by the societal beliefs of the nation. This nation values memorisation for making students work hard and for giving them opportunities to acquire large amounts of knowledge. That is why, similarly to what Tan (2011) proposes, it has been foregrounded in this chapter that it should perhaps also be used to enhance learning in Bahraini schools. This could be achieved by matching reform with the broader societal view on education in a nation, rather than trying to replace it with an improvement programme that is unlikely to be successful due to the socio-cultural values regarding education in that nation.

NOTE

[1] Tawjihiya – national secondary qualification in Bahrain awarded after three years of secondary education.

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10. SCIENCE EDUCATION IN THE SULTANATE OF OMAN

Current Status and Reform

ABSTRACT

Science teaching in Omani schools has undergone noticeable developments in all aspects since Oman adopted a new education system in Basic Education (grades 1–10) and Post Basic Education (grades 11–12)) in 1998. The Omani Ministry of Education set out certain goals of teaching science in order to produce well-educated and scientifically literate people. However, in order to achieve these goals good science teachers and a well-designed science curriculum are needed. The content of science curriculum was revised and developed. Several initiatives were proposed including: road safety within the Omani curricula, environmental education for sustainable development into the Omani curricula, knowledge development program for students in science, mathematics and concepts of environmental geography and using modern technology. Omani science teachers were asked to use inquiry based learning and cooperative learning to make students more involvement in the classroom. The results of Omani students in two rounds of TIMSS (2007, 2011) was not promising which was leaded the Ministry of Education to reform the type and the nature of students' assessment. There are some challenges that Oman faces in the science teaching such as raising students' achievements locally and in the international studies like TIMSS, enhance the quality of science teaching and the use of ICT in science teaching effectively.

INTRODUCTION

The Sultanate of Oman is located in the extreme south-eastern corner of the Arabian Peninsula. It has a total land area of about 300,000 km^2 and a population of 2,773,479 according to the 2010 Census (Ministry of Economy, 2010). Two thirds of Omani citizens are aged less than 24 years. The Sultanate of Oman occupies a privileged geographical site between the countries of the world, making it the focus of trade between the East and West. The Sultanate of Oman is gifted with geographical diversity: open desert consisting of gravel plains and areas of sand dunes, large mountain ranges and coastal land (Ambusaidi, 2010). Omani society, like many

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other countries in the Gulf Cooperation, is witnessing accelerating and long-term sustainable changes across all aspects of life, including education.

The Omani government considers education as an important agent for change in the Omani society (Ambusaidi & Elzain, 2008). Therefore, the education system has undergone a remarkable development since His Majesty Sultan Qaboos bin Said, ruler of the country, come to power in 1970. Schools were built all over Oman in spite of the geographical variation and difficulties among the different governorates of the Sultanate. The Omani government provided all the necessary requirements to improve education in the country, including qualified teachers, curricula and teaching aids (Ministry of Education, 2006). Science is one of the basic subjects in the Omani educational system, and this chapter will discuss the development and some problems with science education in Oman.

Science teaching has undergone noticeable developments in all aspects. In the past, science teaching depended mainly on teaching content and this was done through teacher-centred approaches to teaching. This situation no longer exists since the major development of the education system, which occurred in 1998 (Ambusaidi and Al-Shuaili, 2009). In this year, the Sultanate of Oman adopted a new education system which divided the grades into Basic Education (grades 1–10) and Post Basic Education (grades 11–12). The developments in the science curriculum included the use of the inquiry approach as a main teaching approach, and the use of formative assessment, along with summative assessment. In addition, and in order to seek valid feedback regarding school science, the Sultanate participated in the Trends in International Mathematics and Science Study (TIMSS), which is one of the most famous international assessments of science and mathematics. The Sultanate of Oman participated in two rounds of this study; in 2007 and 2011.In both rounds, unfortunately, Oman scored below TIMSS scale average (500).

SCIENCE IN THE OMANI EDUCATION SYSTEM

The goals of teaching science to Omani students as outlined by the Ministry of Education (Ministry of Education, 2007), are:

1. strengthening students' Islamic beliefs through scientific observation of Allah's creation,
2. developing students' interest in the environment, while appreciating the importance of living in harmony with nature,
3. reinforcing obligations towards the economical use of natural resources in Oman and the importance of international cooperation in preserving natural resources,
4. developing science process skills such as observation, inferring, classification, prediction and experimentation,
5. developing problem solving skills with a focus on the methods of science and thus, students are expected to learn how to approach problems in disciplines other than science by using scientific methods, knowledge and thinking skills,

6. providing students with opportunities to develop the knowledge, skills and attitudes needed in the contemporary scientifically and technologically rich world to which science has contributed significantly,
7. developing the ability to acquire scientific knowledge from books, journals, computers and modern communication systems,
8. developing healthy habits and gaining knowledge about healthy nutrition, general health and safety,
9. providing students with opportunities to gain knowledge about scientific and technological professions, and
10. providing the environment that allows students to value the contributions of Arab and Muslim scientists.

These goals seem very promising and can produce well-educated and scientifically literate people. However, in order to achieve these goals these people need good science teachers and a well-designed science curriculum. They of course also need support from the people around them, such as the school administration and the parents, and need to have access to viable materials and equipment.

Science is one of the core subjects in the Omani education system. It is taught from the first grade to the twelfth grade. From grade 1 to grade 10, there is one single textbook including all science subjects (biology, chemistry and physics), and all three are taught by one science teacher. In grades 11 and 12, the science subjects are taught separately and students can choose to study either all three, or two of them if they aim to major in science-oriented specializations at university level. They can study only one subject, usually ‘science and technology’ in grade 11 and ‘science and environment’ in grade 12 if they want to study art-oriented specializations at university level. The number of lessons allocated to each science subject is summarised in Table 1. Each lesson is 40 minutes long. The Ministry of Education supplies all textbooks and science materials and equipment, but teachers are encouraged to use local environment materials to help students better understand science.

Table 1. Number of lessons allocated to science in each grade

Grades	*Subject*	*No. of lessons weekly*
1–3	Science	3
4–6	Science	5
7–8	Science	6
9–10	Science	7
11	Biology, chemistry, physics and science & technology	Each subject is allocated 4 lessons
12	Biology, chemistry, physics and science & environment	Each subject is allocated 4 lessons

SOME DEVOLPMENT AND INITIATIVES IN THE OMANI SCIENCE CURRICULUM

The Omani science curriculum content in general is not different from the content of science curricula in other schools around the world. It is divided into three main components: life science, physical science (chemistry and physics), and earth and space science. However, on analyzing the curriculum, it is clear that earth and space science is not widely taught in the Omani science curriculum. Only a few topics in this field are offered to students (Al-Mazidi, 2006). There is a need in any future development of the school science curriculum that this field be given more emphasis, because earth and space science is one of the main components of science education standards in many countries around the world, such as the American Science Education Standards (National Research Council, 1996).

The Ministry of Education (MoE) formed a committee in conjunction with Sultan Qaboos University in 2010 to review and develop the science scope and sequence matrix from grade 1 to grade 12. The committee worked on this project for more than two years and completed their review up until grade 8, before the work stopped. Then, the Ministry decided to give the work to an international expert company, to work with people from the Ministry to design what is called the Curriculum Framework. This framework should work as a guide for both curriculum designers and science teachers when delivering the science curriculum to students. Unfortunately, the working group did not include members from any universities or other governmental or private organizations in the country to benefit from their experiences. In addition, including such experts from higher education institutes and universities will help the MoE to know the requirements of higher education's institutes' requirements in term of knowledge and skills of entering students from general education. The role of Sultan Qaboos University, as the main university in the country, and other public and private universities and institutes came after completion of the work to review what the working group had decided. Although this is acceptable but if the involvement of these universities and institutes earlier than this, the benefits of both sides (MoE and universities and institutes) will be more.

There are many initiatives implemented in fields both explicitly and implicitly related to the science curriculum. The first initiative is '*Road Safety within the Omani Curricula'*. This initiative is a partnership between the MoE and the Shell Oil Company Representative Office in Oman (Al-Shebanee et al., 2009). It is one of the most significant social projects based on the objectives of the country's comprehensive development. In order to ensure maximum awareness of traffic safety in Omani communities, the MoE started preparing for the document 'Road Safety within the Omani Curricula' in September 2004. They concluded their preparation by producing an integrated document containing traffic issues to be addressed within the various Omani curricula for grades 1–10 including science, with the aim of promoting comprehensive awareness of various road traffic issues among Omani students (Ambusaidi, 2011).

This document was designed to assist curriculum developers and teachers, by providing them with strategies to stimulate children's knowledge on the development of road safety concepts in school by enhancing their awareness on aspects of traffic movement and the road environment. It also encouraged them to acquire good habits as road users from an early age. The document is also designed to prepare children to be independent road users in the future as pedestrians or drivers, and increase their ability to plan their routes safely, develop sound judgment on potential hazards, develop the skills required to properly assess these hazards, increase their awareness of the impact of their actions on other road users, and develop safe habits for using the road.

The implementation of the document in the science curriculum has a special place in the 12th grade and is incorporated in the Science and Environment textbook. In this textbook, there is one unit called Motion and Transportation which deals with the safety aspect from a physics perspective. In this unit, there is one chapter about road safety. Students, after studying the unit, are expected to be able to deal with road safety from a scientific point of view through understanding the concept of safe distance, braking distance, stopping distance and reaction time.

A second initiative is the inclusion of the *Environmental Education for Sustainable Development into the Omani Curricula* document (Ministry of Education, 2012b). The MoE in Oman is adopting this initiative to develop a document for environmental education concepts in collaboration with several other interested parties, such as the Ministry of Environment and Climate Affairs and the Oman Environment Society, with support from the Shell Representative Office, Oman (Ambusaidi, 2011).

The document includes some of the basic and necessary environmental concepts that had to be addressed when developing the curricula, especially science and geography, and the basic criteria that must be considered and followed when adopting the concepts into the school curricula. Many of the activities that are associated with the document have been developed and assigned for teachers, as a source of knowledge. This was meant to enrich the educational process in schools in order to develop in learners the skills to maintain elements of the environment and the optimal preservation of natural resources and to rationalize consumptions for a sustainable environment. In late 2012, the document was formally announced and now every school subject, including science, will implement the ideas presented in the document.

The third initiative related to the science curriculum is *Knowledge Development Program for Students in Science, Mathematics and Concepts of Environmental Geography* (Ministry of Education, 2009). The MoE has put a lot of effort into developing the curricula, improving instructional methods and attaining international standards in the teaching and learning of science, maths and environmental concepts. Having firmly established these subjects within its priorities and with directives from his Majesty, Sultan Qaboos bin Said, a national programme for enhancing the learning of Science, Mathematics and Environmental Geography was adopted in the academic year 2007/2008. The programme aims at promoting the importance of science and scientific research among students, teachers, parents and the community at large. It also seeks to improve student performance levels in the specified subject areas. The target group of this programme is students in grades 5 to 10. There are many activities related to this programme in science, including: 1) a national test in science concepts and processes, 2) an oral competition between students on regional and national levels, and 3) competitions between schools for students to produce the best science projects. At the end of each school year, there is a big national ceremony to award the individual winning students, schools, educational governorates and parents of students.

TEACHING AND LEARNING OF SCIENCE

Due to developments made to the science curriculum in both basic and post basic education in terms of content and nature, teaching and learning strategies were also subjected to reform. A lot of emphasis was placed on student-centred teaching and learning strategies in order to make student become more active in the classroom (Ministry of Education, 1998). The two main teaching methods used in science lessons, that reflect a student-centred teaching and learning approach, are inquiry and cooperative learning. These two methods as Hassard (2005) argued are easily integrated, because science teachers usually ask students to work in pairs or small groups when conducting lab or classroom activities.

Inquiry based learning has several advantages such as students become more engagement in the learning process and bring the natural world to the classroom (Ambusaidi & Al-Balushi, 2009). In addition, it is aligned to the nature of science and students are expected to acquire science process skills (e.g. observation, classifications, predictions, measurements, interpretations) and problem solving skills (e.g. identification of the problem, collecting evidence, planning) (Martin, 2006). Consequently, Omani science teachers are required to use inquiry based teaching. However, teachers face difficulty to implement it individually (i.e. each individual student doing the inquiry activities) due to the large number of students per class, the shortage of time and the lack of materials. Consequently, the alternative is to implement it in groups of four or five students which is accepted by the Ministry of Education. In addition to how a cooperative learning strategy can help to implement inquiry based learning, it has many benefits to students such as equipping them with many social skills, problem solving skills and scientific knowledge (Hassard, 2005).

Some research has been conducted to explore Omani science teachers' beliefs about using inquiry based teaching and cooperative learning. For example, the study by Al-Harthi (2008) about science teachers' beliefs about inquiry based learning and their classroom practices found that there were positive views towards using inquiry based learning in the science classroom. In addition, teachers who were in favour of inquiry teaching were practiced it better than those who preferred other methods.

The study found that female teachers were more positive about using inquiry based learning, compared to male teachers.

The study by Al-Balushi and Al-Rawahi (2011) on Omani physical education and science teachers' beliefs about cooperative learning concluded that overall, Omani teachers' intention towards using such a strategy in teaching was weak. There was a weak tendency towards using cooperative learning (behavioural beliefs), a weak social pressure on teachers to use the strategy (normative beliefs) and a low willingness by teachers to control the factors that limit using this strategy (control beliefs). The results showed that female teachers' intentions to use cooperative learning and the value of their normative beliefs were significantly higher than in their male counterparts.

In addition to the inquiry method and cooperating learning, science teachers are also encouraged to use other types of teaching methods, such as graphic organizers, reading, role-play, storytelling and classroom discussion. The results of the research studies conducted on these types of teaching methods, such as Ambusaidi and Al-Rashidi's (2012) study on using reading in science teaching indicated that Omani science teachers are willing to use such methods in the classroom but they need training through several workshops. Moreover, the study by Al-Amri, Ambusaidi and Al-Yahyai (2011) found that Omani art and science pre-service teachers had positive attitudes to use the integrated approach between art and science.

MODERN TECHNOLOGY IN SCIENCE TEACHING

We are living in a rapidly changing society, both economically and technologically. Technology shapes our lives, the way we live, the way we do our business and the way we interact with others locally and internationally. The internet, emails, mobile phones and other electronic devices put pressure on and challenge our education system. There is a rapidly growing use of the internet, as content providers of knowledge in many subject areas continue to ramp up their creativity and increase user engagement.

Oman is not behind what is happening around the world in terms of using technology in teaching in general and teaching science in particular. The MoE puts great effort into developing science teaching in the Sultanate using new technology. The aims of this development are to update school science with new technology in teaching as a way to overcome the problems of some science concepts with which students may have difficulty. According to the policy by the Ministry of Education (2003), educational technologies should be embedded in the context of learning and the teaching process. Nowadays, every Omani school has a Learning Resource Centre that is equipped with computers and science software, in addition to books and journals (Ambusaidi and Al-Shuaili, 2009). Some schools are equipped with more than one computer laboratory. According to Krajick and Layman (1993), an electronics laboratory provides students with a myriad of learning opportunities; allowing them to ask and refine questions, make and test predictions, design and plan experiments, collect and analyse data, debate and communicate, draw conclusions and ask new questions. It is a hope that all schools will be equipped with such laboratories in future. In addition, the Ministry started to introduce interactive whiteboards in some schools and it has a plan to equip most Omani schools with this type of board. In addition, the Ministry supplies schools with different softwares that can be used in the science classroom, such as Crocodile in chemistry and the Moodle as a web application and a platform for internet-based courses, to deliver science content to students.

Although such initiatives have been introduced within the last ten years, there are still some challenges facing the Ministry to fully utilise new technologies in science teaching. Some of them are related to the infrastructure that is needed in order to use the internet. In some schools, the internet is very slow and in some of them there is no internet at all, perhaps because these schools are located in the mountain or desert areas. Other challenges are related to teacher training in using modern technology and their beliefs and attitudes towards using it. For the former, training is very important to allow teachers to use the technology effectively; this is impossible without proper and adequate training. Morris and Wardle (2006) found in their research that when they trained teachers to use information and communication technology (ICT) for a couple of weeks, there was a dramatic increase in the personal ICT capability of incoming trainees. They suggested that in order for science teachers to use ICT effectively, the most important two methods of improvement are to designate some websites to enable these teachers access to useful materials; and to share ideas and materials across the science education community inside and outside their schools.

Regarding the latter issue, teachers' beliefs towards the use of technology are very important. Belief is a valuable factor, not only in decisions made about curriculum and instruction, but also in the context of daily life (Ambusaidi & Al-Balushi, 2012). If science teachers have high levels of positive beliefs on the importance of new technology in teaching science, then we expect that they will use it to teach their students, and vice versa.

The MoE should have a strategic plan for embedding the new technologies in all subjects, including science. This plan should include and tackle different aspects. The first aspect is how to strengthen the internet infrastructure. The second aspect should deal with teacher training; the third aspect should be about the impact of such technology on students' learning; and finally the plan should include a clear and planned evaluation process for the whole initiative. Morris and Wardle (2006) pointed out that in order to use information technology effectively involves three important factors: clear objectives, plan appropriate tasks, and monitor the students' work. More research studies are needed to investigate the impact of using ICT in students' learning of science, as Oman lacks such studies. The researchers could investigate science teachers' beliefs, attitudes and knowledge about ICT and how these affect students learning.

ASSESSMENT OF STUDENTS' LEARNING IN SCIENCE

The assessment process is a very important component in the whole educational system. It shapes both the teaching and learning process. There is a direct and strong connection between teaching and assessment (Ambusaidi & Al- Shuaili, 2009; Ambusaidi, 2000; Bennett, 2004). In science education, the aim of assessment is to enable students to build scientific understanding through direct interaction with materials, events and phenomena in their environment (Harlen, 2006) and to make them think about this.

In the Sultanate of Oman, assessment of students' learning of science has also undergone major developments, and has shifted from mainly summative assessment, based on examination, to a combination of both summative and formative types of assessment. As a result of Oman's participation in TIMSS in 2007, the Ministry reformed what is to be assessed and how to assess, due to the lower achievements that Omani students had in TIMSS in both science and math. It adopted the three cognitive levels that are used by TIMSS. These levels are retrieving, applying and combining. Each of these levels consists of several abilities and skills which are explained in Table 2 (Ministry of Education, 2012a).

Ambusaidi and Al-Mazidi (2013) analysed the units' questions used in the Omani science textbooks for grades 5-8 based on the three levels of TIMSS. The results indicated that, in general, the percentage of inclusion of retrieving and apply levels are above the percentages required by TIMSS, whereas in the combining level, the percentage is lower than what is required in TIMSS. The study recommended that the units' questions for all Omani science curricula should be reviewed to include more questions in the higher level (reasoning) so that students will be exposed to the type of questions that are found in TIMSS. Moreover, science teachers should work towards this by including this type of questions in teaching and assessment.

Students are assessed in these levels by different tools in order for teachers to gather valid information about their performance. Some of these tools are applied during the school year (formative assessment) and some of them are only applied at the end of the semester or school year (summative assessment). Omani science teachers are required to use final exams, short quizzes, oral work (i.e. oral presentation and discussion), homework, projects and lab work (i.e. practical exam and scientific activities) to assess students (Ministry of Education, 2012a). Moreover, and in order to make control of the assessment process especially in the higher grades, the final exams for grades 10, 11 and 12 are constructed centrally by the Ministry's Directorate General of Educational Evaluation, whereas for the remaining grades (1–9) they are constructed by either by the schools or by each regional Educational Directorate.

Science teachers are key players in implementing formative assessment in the classroom. They use their personal knowledge of students, their understanding of the context of the assessment and the curriculum target to identify particular needs. It is the teachers' role to know about the students and where they are in relation to their science learning goals, to decide on the next appropriate step to enhance students'

Table 2. Levels of assessing students in science

Level	*Ability and Skill*	*Brief Description*	*Percentage of Total Mark*
Retrieving	Recall	Recall of scientific facts	30%
	Define	Give the definition of scientific concepts	
	Describe	Describe the characteristics of something	
	Explain with examples	Give examples while describing scientific phenomena	
	Use of materials and procedures	Express scientific knowledge using materials and procedures	
Application	Compare	Define the similarities and differences of two things or more	50%
	Use Models	Use models to understand the scientific phenomena	
	Get Relationship	Get the relationship between things or between the information of a concept and its behaviour	
	Interpret	Interpret the information based on scientific theory	
	Get Solution	Use equations or formulae to find a solution	
	Present	Present what the student understands about a certain scientific phenomenon	
Combining	Analysis/ Problem Solving	Analysis of problem to find a solution	20%
	Integration	Integration between mathematical concepts or procedures to solve scientific problem	
	Hypothesis/ Predict	Propose hypothesis and prediction based on evidence available	
	Plan/Design	Plan and design scientific inquiry to answer scientific questions or to test the hypothesis	
	Inference	Ability to conclude something from the available data/Give solid conclusion based on evidence	
	Generalize	Reach general conclusion beyond the given experiment's conditions and apply the conclusion in a new context	
	Evaluate	Evaluate inquiry conclusion/ Evaluate procedures used to solve problems	

learning, and improve their teaching to help students take appropriate steps, and importantly, to involve the students in this process (Harlen, 2006). A study in this area by Ambusaidi and Al-Rashidi (2009) using questionnaire as research tool to gather data showed that they Omani science teachers' faced many difficulties in applying the formative assessment in the classroom. These difficulties include: 1) teachers do not have time to check on students' work and projects at school; 2) teachers have too many items to fill in on student record sheets, and 3) the large number of students in each class. In addition, the results showed that there was no difference due to teacher gender, years of teaching experience or the place where they graduated on their application of formative assessment. In other words, it cannot be said that male teachers are better than female teachers when applying formative assessment and the same applies for teachers' experiences and their educational background.

The MoE should continue improving teachers' knowledge and skills for the effective use of formative and summative assessment. This can be done through carrying out several workshops and training sessions, sharing good practices between teachers, and pair visits within the schools, and between schools in each region (Ambusaidi & Al-Rashidi, 2009).

TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS) RESULTS

The Sultanate of Oman participated in two rounds of the Trends in International Mathematics and Science Study (TIMSS) in 2007 in grade 8, and in grades 4 and 8 in 2011. In 2007, Oman scored 423 points in science. This value is below the TIMSS scale average which is 500 points (Ministry of Education, 2010). The results of this round seemed acceptable among science educators in the country as it was the first time the Sultanate had participated in such a study. However, in 2011 Oman again scored very low, lower than in 2007, with a score of 377 (TIMSS and PIRLS International Study Center, 2013). The results of the second round were deemed unacceptable among science educators in the country and there was an urgent need to find out the problems that had led students to perform so poorly. The Ministry is doing its best to do so and we expect that a lot of work will be done in the science curriculum and with science teachers.

One of the weakest points of Omani students identified in TIMSS was their inability to transfer the knowledge they possess into a new situation. Furthermore, students failed to answer the questions related to diagrams and their understanding of daily natural phenomena (Ministry of Education/The World Bank, 2012). According to the Minister's report on the results' of TIMSS 2007, this was due to the fact that some teachers did not practise these types of questions with their students in the classroom (Ministry of Education, 2010). The Minister of Education formed a committee to conduct a national symposium regarding the results in order to reach conclusions and propose recommendations to improve science teaching. The committee conducted a sort of open discussion forum with teachers, supervisor, curriculum designers and people from higher education institutions. The discussion was oriented towards how Omani students can achieve well in international studies like TIMSS and Progress in International Reading Literacy Study (PIRLS). It is hoped that the Ministry will work towards developing a well-planned strategy for the coming years to improve science teaching in schools and hence improve Omani students' performance in the international studies.

CHALLENGES AND FUTURE DEVELOPMENT NEEDED

The Omani Ministry of Education is making a significant effort to improve science teaching in Oman with some collaboration from other teacher education institutes especially Sultan Qaboos University. However, there are some challenges that need to be confronted. The first challenge is related to students' achievements in science for both genders but more with male students. TIMSS results indicated that female students perform better than males (Ministry of Education, 2010). The ministry should work hard to find ways to help students in general and male students in particular to achieve well in science. The second challenge is the quality of science teachers. It is related to the first challenge. Based on the results of some previous studies about Omani science teachers (Al-Balushi & Al-Rawahi, 2011; Ambusaidi & Al-Rashidi 2009; Al-Harthi, 2008), some science teachers are not up to the standards that allow students to achieve well. Those teachers should be exposed to well-planned professional development programmes. Started in 2010, the Ministry of Education, in collaboration with Sultan Qaboos University, set up an exam for new teachers. The purpose of the exam is to select teachers who are capable of teaching science in public schools. It consists of items from subject matter, curriculum, and teaching methods to psychology. In applying such an exam, it will help Ministry of Education to select better teachers for teaching students science subjects. Those teachers who fail the exam undergo intensive training programmes at Sultan Qaboos University in both subject matter and pedagogy lasting from two to six months.

However, this exam only applies to new teachers and not to existing ones. Therefore, continuing professional development (CPD) is very important in order to keep science teaching effective and updated. Bell (2006, p. 41) argued that "what we learnt in college" is not enough. Teachers need to keep updating their skills, knowledge and understanding if they are to teach effectively in order to continue providing high-quality learning opportunities for students. The CPD programmes vary in content between subject matter and education, and their outcomes may help to improve the quality of science teaching. The annual budget for professional development was increased by His Majesty Sultan Qaboos bin Said to seven million Omani Rials (around USD 18 million). If these programmes are well planned and implemented effectively and taking into consideration teachers' needs and weaknesses, then this will reflect on their students' achievement.

In parallel with what the MoE is doing to improve the quality of science teaching, teacher education institutes should reconsider their current science teacher education programmes and try to develop them to be more effective. This can be done in many different ways, such as inviting external reviewers to review the programmes and conducting follow-up studies on graduates. This may also be done through the process of accreditation from well-known international organizations.

The third challenge is related to the use of ICT in science teaching. This challenge should be addressed by focusing on two areas: the first is related to strengthening the internet infrastructure and the availability of appropriate software. The Ministry should work together with internet providers like Omantel and Ooredoo (Previously called Nawras) to enhance internet provision in schools. Furthermore, the MoE should support teachers with appropriate software that can be used in science lessons. The second area of the ICT challenge is related to teachers' skills in using ICT – that is, to what extent they use it and if so how effective it is. It might be that both the internet and software are available to teachers, but because teachers do not know how to use them effectively, they expect no effect on students' learning. There is a need for well-designed and implemented training programmes in ICT to help science teachers use modern technology effectively in the classroom.

Finally, there is a need for more research studies on the impact of socio-cultural issues on the development and reform that is happening currently in the science education in Omani schools. The science education unit at Sultan Qaboos University and in other private universities that offer masters degree should encourage masters' students to conduct their research in this area.

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11. THE SOCIO-CULTURAL CONTEXTS OF SCIENCE CURRICULUM REFORM IN THE STATE OF KUWAIT

ABSTRACT

In 2008 the Ministry of Education (MoE) in Kuwait began the reform of the science curriculum in schools at all academic stages: primary (grades 1–5), intermediate (6–9) and secondary (10–12). The new science curriculum was adapted from an original curriculum which was designed and published by the US company Pearson-Scott Foreman. The purpose of this chapter is to explore the perspectives of science teachers about Kuwait's new science curriculum for the sixth and seventh grades (aged 11–13 years), which was implemented in 2010. The focus was on the teachers' views regarding the extent to which this curriculum related to the country's social, cultural and religious norms and how far this affected the teaching of science. Data were collected from interviews with eight teachers. The findings indicate that the curriculum content was not much related to the Kuwaiti's habits of thought and this had a negative effect on students' understanding and their attitude to learning science. The findings also showed that science teachers faced many challenges in teaching the new curriculum, such as the failure by MoE to provide any training for teaching it and a lack of suitable teaching tools. To conclude, the findings suggest that the curriculum should be related to social and cultural norms and stress the importance of involving teachers in curricular reform.

INTRODUCTION

Kuwait is one of the Gulf Arab States (Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates and Oman). The education system in Kuwait is divided into three stages; primary grades (1−5), intermediate (6−9) and secondary (10−12). Science is a compulsory subject in all stages; in the elementary and intermediate stages, it is taught as a general subject and in the secondary stage it is divided into separate physics, chemistry, geology and biological courses.

In the last few years Kuwait and some other Gulf States have started to reform their science curriculum. In the UAE, the MoE adopted a science curricula series published by Harcourt, an American publisher (Alqasemy, 2013). In Bahrain and Saudi Arabia, the science curricula published by McGraw-Hill (a US company) were adapted to suit each country's culture, society and environment (Obeikan Education, 2012).

N. Mansour & S. Al-Shamrani (Eds.), Science Education in the Arab Gulf States, 205–223.

In Kuwait, the MoE chose to reform the science curriculum after many criticisms and studies (such as Al-Ahmad, 1999; Al-Khamis, 2000; Al-Rashed, 2000; Mohamad, 1998) which confirmed that the old science curriculum was weak and did not adequately develop students' skills, because it focused on memorization. Most of the studies in Kuwait recommended a reform and development of this curriculum. It had been taught in all the Gulf States, where a unified set of curricula had been in operation since 1985. At this time, based on Resolution No. 34/1/2, issued by the Gulf Cooperation Council (GCC) Education Bureau General Conference in its 8th session in Qatar, unified science curricula were developed for all member states. These curricula were compiled and prepared by a group of local science inspectors and researchers. The objective behind unifying the curricula was to concentrate the efforts of all the states and allow them all to benefit from prepared curricula which would generally develop their educational provision (Arab Bureau of Education for the Gulf States, 2010).

A study by Mohamad (1998) considered the content of the old science curriculum for intermediate students. His results indicated that the transfer of information in these curricula was a travesty of teaching. It presented knowledge in a direct way, invalidating one of the most important objectives of teaching science, i.e., the development of the students' own abilities to research and deduce. Mohamed recommended reforming it so as to help students develop thinking and problem-solving skills.

A study was conducted by Al-Ahmad (1999) on a group of 6th year and 8th year students with the aim of identifying whether the science curriculum developed problem-solving skills to resolve scientific questions. The researcher tested the problem-solving skills of a group of students and found that the curriculum did not train them well in this area, but focused instead on memorization and recall. The study recommended reforming and upgrading the science curriculum in order to develop a variety of scientific skills.

These conclusions were in agreement with those in a study by Al-Khamis (2000), evaluating the provision for 7th year students in Kuwait. He confirmed that their science curriculum, in spite of the importance of a wider training, still focused only upon items of knowledge and was considered a source of information and knowledge which developed memory but not such intellectual areas as would be needed for creative. He also recommended reforming the science curriculum.

A study by Al-Rashed (2000) dealt with the content of the old science curriculum for 8th year students. The researcher analysed its content and found deficiencies in the number of lessons and scientific experiments to help students use science for solving everyday problems or make use of scientific facts. The researcher stated that most of the content of the science curriculum focused on theory and was not much concerned with practicalities. This study also recommended the reform and development of the science curriculum in Kuwait.

When Kuwait joined other Gulf States in reforming the science curriculum, it selected a curriculum series designed in the US by the publisher Pearson-Scott

Foreman, proposing to have it taught in Kuwait after modifying, adapting and reviewing it to suit the nature and needs of Kuwaiti society (Al-Burak, 2011).

It will be clear from the above that most of the Gulf States started with curricula which had been designed in a Western context. This idea is supported by Dagher and BouJaoude (2011). They argue that the reform of the curriculum in many Arab states has been influenced by the curriculum reform taking place in Western countries. This influence is clear when developing education systems, designing school curricula, encouraging students to study, and changing the content designed for a more secular population (Bashshur, 2009).

The culture and society in Arab countries, however, are different from those in Western countries (Dagher & BouJaoude (2011). Many studies and authors maintain that a science curriculum related to the cultural environment is valuable, while some even claim that the goals of the curriculum may not be achieved if it is not relevant. Akker (2003), for instance, wants the new curriculum to be connected to the society and culture of the student, while Fullan (2007) affirms that it should take into account the student's society, culture and environment if the reform is to be successful.

In Waldrip and Taylor's study (1999) of the permeability of students' worldviews to their school views in non-Western developing countries, the authors stress the significance of taking the student's culture into account when the science curriculum is designed or reformed. They found that the local culture of the students largely affects their learning of science subjects and that this culture is relevant to and effective in life outside the school. The relationship of the curriculum content when it is relevant to the students' lives is more beneficial and they gain more from the study of science subjects (Waldrip & Taylor 1999).

Shah (2012) states that it is important to relate the newly implemented reform socially and culturally to the teachers, educators, parents and students in order to achieve the educational objectives. Moreover, the material being learnt is intended to help students respond to a new world, new technology, the latest economic developments and the political situation in the world and yet must demonstrate that it will maintain the status quo in the nation's historical and cultural identity.

The culture of Kuwaiti society has been deeply influenced by Islam, which is reflected in the customs, traditions and everyday life of the society, as well as the education. Islam is the religion of the state of Kuwait and Arabic is the only official language, as laid down in the constitution. This also guarantees the freedom of other religions. Education and healthcare are provided as Article (3) of the constitution sets forth: "*The State shall provide free healthcare and education for Kuwaitis from the first school year up to the university study stage.*" Kuwait's social life is influenced by Islam and her society is characterized by the close relationships of family members and friends. Kuwaiti people and the ruling family share each other's social occasions. The people are peaceful, having allowed expatriates of more than 20 different nationalities to live and work in Kuwait for a long time and to lead normal lives; those of different religions observe their rituals with complete freedom under the constitution.

Hence, all these aspects of the society should be taken into account in educational reforms, including curriculum reform.

In such a social and cultural context, can the science curriculum relate to the Arab Muslim culture? Some studies discussing this point claim that Islam is totally compatible with science: that the Qur'an and Hadith encourage people to research and explore ideas. Moreover, many scientific facts as taught in the science curriculum are included in the Qur'an. This point was discussed by Salleh et al. (2011), in which they contend that there are many verses of the Qur'an which clarify and prove scientific facts in many fields, such as the medical, biological, physical and cosmic. The Qur'an mentions many scientific arguments and scientific phenomena which require deep thinking and hard work to understand, such as: cell proliferation, rain and clouds, earthquakes, volcanoes, the sun, moon and stars, and many others. If the appropriate verses of the Qur'an were included in science lessons, they could make certain natural phenomena more accessible and help students to better engage in learning science. The Qur'an also says that God rewards students who are looking for truth and differentiates between scientists and other people, because they have more knowledge of the nature of science and thus may have a stronger faith in God than others, and this can encourage people to learn, and search for themselves (Salleh et al., 2011).

Before further discussion of the relationship between science and Islam, it would be better to discuss the relationship between science and religion in general. Reiss (2008) described the relationship between religion and science as a mutual one which benefits both partners. The relationship is seen by different individuals in three main ways: first, where the scope of religious knowledge is much smaller than that of scientific knowledge with no overlap between them; second, where religious knowledge has a much smaller scope than scientific knowledge and is mostly contained within it; and third, where the worldview is mostly religious, holding that religious knowledge is much greater than scientific knowledge and contains it all. Thus, the variations in understanding this relationship are due to the considerable variations in the visualization of both religion and science. However, Sharpe (2002) proposes something called the camellia model, in which science and religion are integrated in their relationship, each accepting a knowledge of the other. Moreover, it is claimed that religion and science can together build a prosperous world of energetic, life-directing, inquiring and truthful knowledge. Alexander (2007), for his part, supplies four possible models of the relationship between science and religion: conflict, non-overlapping magisteria (NOMA), fusion, and complementarity; concluding that the 'complementarity' model, that is, one of compatibility, is the most fruitful in relating religious and scientific knowledge, or at least the one offering the most benefit. This is supported by Dagher and BouJaoude (2011), which indicates that there is a general tendency to promote the compatibility of religious views and science.

However, Reiss (2010) notes that some students do not at all accept certain items of scientific knowledge or scientific theory, such as the theory of evolution, because it conflicts with their religious beliefs. He emphasises that these views should be respected, but suggests that the theory should be taught to all students so that they can understand, but not necessarily accept, the scientific worldview with respect to human origins. Teachers should be cautious before teaching it in science classes and both curriculum and teacher need to be developed, the latter by receiving continued professional development to take care of such problems. This will help the students "to appreciate the way science is done, the procedures by which scientific knowledge accumulates, the limitations of science and the ways in which scientific knowledge differs from other forms of knowledge" (Reiss, 2010, p.100).

The relationship between science and Islam is discussed by Loo (2001) in his study; he finds that Islam is relevant to science and cannot be separated from it, least of all in the curricula of Arab states. He also mentions the scientific facts included in the Holy Qur'an, which are studied in schools nowadays, such as those concerning the universe, the human body and the growth of organisms.

Many researchers find no conflict between Islam and science and, further, find that Islam encourages research and exploration. They confirm the importance of connecting the science curriculum to the culture of the Muslim society in Islamic countries, because it will help students to understand the science more easily (Loo, 2001; Shaw, 2006; Mansour, 2008). The advantage of doing so, as identified by McGinn (1991), is that they will make use of their knowledge in their everyday lives (McGinn, 1991).

Mansour (2011) considers the views of science teachers in this regard, reminding us that in many verses the Holy Qur'an articulates scientific ideas which were demonstrated later by scientific studies. He maintains that the Holy Qur'an encourages scientific research to reach the truth from every source and he wants the science curriculum to be necessarily relevant to the Islamic Arab culture of students in the Arab states.

Shaw (2006) advises that the Arab Islamic culture must be reflected in education reforms in the Arab states, stating that one of the most important goals of education in most Arab states is to create citizens who can serve and develop their country. To this end, Shaw believes, the curriculum content must connect with the culture and society of the students; he illustrates how to make use of science in developing one's country and solving the problems of everyday life. He states that correlating whatever may be studied with the relevant culture and society contributes significantly to the attainment of educational goals (Shaw, 2006).

Indeed, the science curricula must relate to every aspect of students' life and environment. The science curricula should be concerned with the desert environment that characterizes most Arab states, the natural resources and ways to sustain them. In one of Shaw's examples, the Gulf states, unlike other Arab states, are characterized by their dependence on oil, which results in generally higher standards of living. By associating this fact with other studies, the students should learn how to make use of oil in their country's development; whatever they learn about this will contribute to their capacity to develop their country (Shaw, 2006).

Studies affirm that Islam does not contradict science, but rather that the Qur'an encourages research and exploration (Dagher, 2009; Dagher & BouJaoude, 2011; Loo, 2001; Mansour, 2008, 2011). Therefore any reform process should connect the science curriculum with the social and religious culture and in Islamic states may lawfully do so. From the previous argument it is clear that their compatibility should be taken into account when reforming the science curriculum. However, the new science curriculum in Kuwait was designed primarily for the US, where a different culture prevails, and so the main questions for this study are as follows:

1. To what extent do science teachers think that the new science curriculum is relevant to Kuwait's social and cultural context?
2. To what extent does the new science curriculum relate to the religious context?
3. What are the challenges and difficulties which face science teachers in teaching the new science curriculum?

METHOD

Semi-structured interviews with eight science teachers were used to collect the data in this research. In semi-structured interviews, Denscombe (2010, p. 176), remarks, "the interviewer still has a clear list of issues to be addressed and questions to be answered". Meanwhile, "the interviewer is prepared to be flexible in terms of the order in which the topics are considered, and, perhaps more significantly, to let the interviewee develop ideas and speak more widely on the issues raised by the researcher. The answers are open-ended and there is more emphasis on the interviewee elaborating points of interest." In this study, science teachers were asked in their interviews to thoroughly explore their perspectives of the new science curriculum in the social-cultural and Islamic context and the challenges and difficulties they faced in teaching it. A tape recorder was used during the interviews, which lasted for 45 to 60 minutes. After each interview, the author summarized the answers given and asked the interviewees to confirm whether this summary and interpretation reflected what they meant.

In this research study, I used thematic qualitative analysis, which Braun and Clarke (2006) consider to be a foundational method for qualitative analysis. It provides core skills which may be used effectively for conducting qualitative analysis and one of its advantages is its flexibility, which makes it "compatible with the essentialist and constructionist within psychology" thus it is a very useful tool providing rich and detailed information although it fills the research with complex material. The phases in conducting thematic analysis are first to identify the information, which gives the researcher a strong sense of the importance, depth and extent of his data. If the researcher deals in verbal information, such as is produced in interviews, for example, the transformation/transcription system used allows, as its main advantage, the retention of the information needed (Walliman & Appleton, 2009).

RESEARCH SAMPLE

A sample for this study was chosen at random from the intermediate schools in Kuwait. First the schools were chosen randomly. Then these schools were all visited to meet members of the target population for the study's interviews and classroom observations, the science teachers who teach grades 6 and 7. Eight science teachers altogether completed interviews (five men and three women).

RESEARCH RESULTS

All these interviewees affirmed that at no stage of the curricular reform process had they participated in the decisions; instead, they found out from their newspapers that the Ministry of Education (MoE) was reforming the curriculum. This being the case, they were surprised at the start of the academic year by the appearance of the new curriculum, which they were asked to teach. Teacher (2) mentioned:

> I did not participate in any step in the reform of the curriculum and did not meet any teacher who informed me that he had been involved in it. We have become accustomed by the Ministry of Education not to expect teachers to be involved in any decisions taken.

It is clear that the science curriculum reform process in Kuwait was centralized by the policymakers in the Ministry of Education without even consulting the teachers.

SOCIO-CULTURAL

All the teachers agreed that the content of the new science curriculum was generally lacking in relevance to the social culture and that the new curriculum did not relate closely to the students' social and cultural norms in their everyday lives. These teachers think that several more topics should have been taught to the students, which are linked to their society, culture and environment, such as desertification, pollution, desert conditions, and natural resources such as oil and gas. (The point about teachers' lack of input will be discussed in the Centralization section below.) Teacher (1) mentioned:

> The content lacks topics that have a bearing on oil, the most important source of wealth in Kuwait, on which the economy depends. There should be topics [in the curriculum] which address the importance of oil and how to benefit from it.

Three teachers also mentioned that the content of the new science curriculum does not relate to Kuwaiti social and cultural conditions, and gave examples of some problems which must be raised with students, such as air pollution and soil pollution, in particular after the Gulf War where so many weapons causing pollution were used. The teachers had assumed that these problems would be brought into lessons and scientific methods of solving them would be taught, and they emphasised that the old curriculum had tackled them, but the new one ignored them.

All the teachers mentioned that the more the content of the curriculum relates to the students' culture, environment and life, the more it contributes to their easy understanding of the lesson; consequently, it plays a role in the development of the country and the production of future scientists, who apply science to solve their problems for this purpose. Teacher (4):

> Sometimes I have to mention examples from the students' environment, society and culture so as to make the lesson comprehensible, because the examples given in the textbook are unfamiliar to them.

Three other teachers had a different perception of relating the science content to the society and culture of the students. They mentioned that they could not relate all the topics of the curriculum to their students' lives in particular because they thought that science was a general subject and concerns everything in the world. They agreed that it was important to link the curriculum as far as possible to the students' social and cultural norms. They said that the new curriculum related in some ways to Kuwait's social and cultural life and that further links could be developed in the future. Teacher (1):

> The subject of science is concerned with so many things in this world that we can't make science local and connected and close to our social and cultural world because this would restrict the students to this country, which is wrong.

Two of the teachers stated that the most important aim of the science curriculum was to help the students to use science in their everyday lives. However, most of the teachers believed that this objective is not one of the objectives of the Ministry of Education. Teacher (3):

> This objective means that there is something there that I've wanted to achieve. For this objective to be attained, I must link the course as closely as possible to the culture of the society in which the student is living, but unfortunately the objectives which touch on the student's community and environment are few.

Regarding the textbook, five of the teachers stated that many of the examples and images used in the textbook are not relevant to the students' social-cultural situation. These teachers believe that to embrace the students, examples should be given from their familiar environment in order to contribute to their understanding of the lesson and access to its content. Teacher (7):

> Some pictures and examples bear no relation to the students' environment and society, although images from the students' society might have been brought

> in. The students see some plants and animals illustrated in the pictures of the textbook for the first time in their lives. As I see it, familiar examples make it easier for the student to understand the lesson.

THE ISLAMIC RELIGION

All the teachers had the same perception that the current science curriculum does not respect the relationship between the student and his or her Islamic religion, for no examples are given from the Holy Qur'an and Sunnah of the Prophet Mohammad in the science lessons, nor are there any references to any Muslim scientists or scholars. The teachers affirm that when evidence from the Holy Qur'an and Sunnah is provided in connection with science lessons, it increases the confidence and trust of the students in the facts and findings of the lesson, which helps them to absorb it. The teachers also indicate that acknowledging the work of Muslim scientists would have been ancillary in encouraging students to study and love science. Teacher (4):

> Islam is the official religion of Kuwait and most Kuwaiti students are Muslims. Thus, when a Qur'anic verse is mentioned in the lesson, this helps the student to understand the lesson easily and trust the facts illustrated in it.

Another teacher agreed that the new science curriculum did not relate to what the students learned with the Qur'an and Hadith and gave examples to show how this could be done. Teacher (6):

> There are many lessons that can be connected to verses from the Holy Qur'an, such as lessons on day and night, the seasons and reproduction.

Four of the teachers also agreed that the new science curriculum does not give credit to Muslim scientists of the past, such as Ibn Sina, Ibn Al-Haytham, Al-Razy and others, for developing or creating scientific principles and inventions. The teachers said that mentioning these scientists would contribute to encouraging students to pursue their journey of discovery, research and learning. Teacher (2):

> The new science curriculum didn't mention anything about the Muslim and Arab scientists. I think when they come to know the achievements made by earlier Arab and Islamic scientists this will contribute to spreading a spirit of enthusiasm.

Two teachers did not accept this point. They agreed that is important to relate the curriculum content with the Qur'an and Mohammad's Hadith and that the new curriculum was not closely related to these holy books, but they said that it was difficult to relate all or most of the science lessons to them. They believed that the teachers could do this in class but not that it must be written in the textbook. Teacher (7):

> I sometimes quote certain verses from the Holy Qur'an and notice the students' quick and easy understanding of the lesson afterwards. This matter is possibly

> one for the teacher. It is not a requirement that the verse should be written as part of the lesson, but it is better to write the verse [in class] for the students to read.

CHALLENGES

The teachers defined many of the challenges they have faced in teaching the new curriculum. They wish that the MoE had cooperated with them to solve the issues raised by these difficulties.

Centralization was the main challenge in teaching the new curriculum, according to the respondents. All the teachers concurred that the workings of the MoE and its staff are centralized, as is presumably the case with other ministries, although these were not considered in the present study. All the educational decisions are taken by the MoE and sent for their implementation to the teachers, who have taken no part in any educational decisions. The respondents highlighted that some of these decisions affected the teaching of science in the schools and that one of them related to the reform of the science curriculum. They were sure that all the educational decisions in respect of the science curriculum reform process were taken by the MoE without giving the teachers any role in it and were then sent to the teachers to be put into action.

In addition, all the respondents asserted that they were limited to the topics in the school science textbook and were not allowed to bring any other resources to the teaching of science. As one teacher (3) complained,

> This hinders me from being creative in teaching science and makes the science class boring. I can't use other resources than the Ministry of Education system to teach science in school. We have just the science textbook as a resource and we are obliged to teach the topic from this textbook only.

Some of the other MoE decisions have been influential in the teaching process, such as the teaching plan for the new science curriculum, which all the teachers confirmed had been sent by the MoE only at the beginning of the academic year. It included the textbook lessons which had to be taught and the time allowed for teaching each lesson. The teachers were told to stick to this plan without exception, although, as they all agreed, they had had no part in designing it. Teacher (4):

> At the beginning of each school year, the Ministry of Education sends the teaching plan of the curricular content, which includes the lessons that I have to teach with the time required for each lesson and some suggestions for the way of teaching. The teachers have been instructed to follow the teaching plan set by the Ministry of Education and may not make any revisions of it.

Teacher (8) described the effect of this decision on his teaching:

> These issues hinder my creativity in teaching and obstruct the development of my teaching skills. The teacher should have some freedom in teaching students.

All of the teachers interviewed criticised the MoE for also centralizing the new student assessment system and confirmed that the exams, exam times, exam lessons and exam marks are controlled and designed by the science inspectors in the MoE, ignoring any role for the students themselves in determining the way that they were assessed. Teacher (1):

> I can't control the students' assessment and I have to comply with the conditions for the students' exam, which is prepared by the Ministry of Education; otherwise, I will be accountable. Likewise, my students must sit no other test because the examinations are prepared by the Education Inspectors of the Ministry of Education. These issues hinder my creativity in teaching and obstruct the development of teaching skills.

Regarding the centralized working system of the MoE, the majority of teachers interviewed agreed that this centralization reflected negatively in the views of the teacher about their job and the curriculum. Teachers felt frustrated by being ignored in the educational decision-making process and by the general lack of interest in their views on the part of the MoE.

The lack of available teaching tools is another challenge, as all the teachers agreed. They all point out that it is a problem to have so poor a provision of the teaching tools necessary for teaching the new curriculum, such as smartboards, computers, overhead projectors, TVs and videos. Therefore, teachers say that they have managed by procuring the necessary tools at their own expense. Teacher (7):

> With the implementation of the new curriculum, there is a severe shortage of some teaching tools, with others not available at all. Many of the teaching tools which were used in the old curriculum are of no use now. In addition, we have requested the Ministry of Education repeatedly to provide these tools, but unfortunately this has not been done.

Most of the teachers stated that the additional work assigned by the school adversely affects them. Among these added items is having to attend daily in the school yard during break times to monitor students, and an administrative mandate of teachers to supervise an entire educational stage, e.g., the teacher may be the supervisor for the whole 7th grade. The role of the supervisor is to follow up and resolve students' problems, ensure that teachers reach their classrooms on time and track the presence and absence of students, notwithstanding the commitment of teaching their own classes. The school administration also requests each teacher to lead a group of students in some activity; e.g., the teacher may be responsible for the students' horticulture group, the library or some other activity.

The additional work required from the teacher is to work as a salesman in the school cafeteria during breaks. In each school a group of teachers is elected to sell commodities, procure the goods demanded and conduct the financial accounts of sale and purchase operations for the school cafeteria, submitting the accounts to the school administration every day. The teachers are required in addition to stand outside the school two or three times a day until the last student has left, even if this takes several hours; their duty is to make sure that all students have left with their parents and none remains behind. Teacher (1):

> I am administrative superintendent over the 6^{th} grade, carrying out the task of tracking the presence and absence of students and teachers to the classrooms, resolving the problems of students and following up the students who have difficulties in learning due to illness or other reasons, in addition to my basic job of teaching, preparation, correcting exams and awarding marks.

All the teachers confirmed that these additional tasks adversely affect their performance, put them under pressure and cause them to fail in their basic work, which is to teach the students.

DISCUSSION

The study results from the interviews with the science teachers were collected to find out the teachers' views regarding the new science curriculum which was implemented in 2010, and matters associated with its implementation. The results of the study served to clarify their negative views regarding the new arrangements, with which it was clear they were dissatisfied. In this section the most important results of the study will be discussed in detail and compared with those of previous studies which were discussed above in the introductory section.

Social-Cultural Norms

According to the findings from the teachers' interviews, they all thought that the new science curriculum was irrelevant to their culture and needs; they argued that the objectives in several lessons were not suited to their social culture, which is Arab and Islamic. The findings show that they generally agreed that it was important to relate the content with the social culture of the students who had to learn it, because this would help the students to understand lessons more easily.

This point concurs with the studies of Akker, 2003; Fullan, 2001; and Shah, 2012, which argue that the social culture should, for exactly this reason, be considered in any reform and development of a curriculum. Indeed, these studies state that the curriculum reform process may fail if the content does not relate to the culture of the society, the students' needs and their environment.

The science teachers cited some examples, such as that the state of Kuwait is economically entirely dependent on oil, but there are too few lessons on the uses, importance and processing of oil. Several other examples were also given: the new science curriculum is typified by inadequate lessons on desert reclamation, the fight against desertification, the benefits of solar energy, and other topics which are deemed to be among the key needs of Kuwait society.

This omission contradicts what most studies affirm (Waldrip & Taylor 1999; Shah, 2012; Idris et al., 2012), which is that the students ought to be studying topics in science which can be related to the needs of their society, since this will contribute to the creation of adults capable of contributing to their country. These studies also conclude that relating the science curriculum to the needs of society promotes its success and helps the students to understand the lessons easily, with a sense that these lessons are important and related to everyday life; this will impact positively on their attitude to learning science and understanding the lessons.

These findings suggest that most of the teachers feel that the new science curriculum is irrelevant to their culture and their society's needs, despite the stress on relevance among many previous writers. The irrelevance of the new science curriculum to the culture of Kuwaiti society may be one of the reasons for the negative views of most of the teachers about the reform described in this study.

Such lack of relevance to their culture and needs may be attributed to the fact that the new science curriculum was designed and published in the USA, a country which differs culturally, socially and environmentally from Kuwait. Importing a curriculum and experiences from a Western country may be useful if it is done in the right way, given that the USA and other Western countries are more developed and have students who perform better than Kuwaiti students do in international tests such as PISA and TIMMS. Many Arabic countries, such as the UAE, Saudi Arabia, Oman, Bahrain, Lebanon and Kuwait itself, import and teach a science curriculum from the USA or another Western country in order to take advantage of its expertise (Al-Qasemy, 2009; Dagher & BouJaoude, 2011; Obeikan, 2011).

It must be admitted that some teachers commented in their interviews that in some lessons the old science curriculum also lacked relevance to Kuwait's society, culture and needs, also because of a lack of reinforcement from Qur'anic verses or Hadith, or from Islamic scientists or scholars, even though the old curriculum had been designed by specialists from the GCC. From this observation it may be inferred that the original American curriculum or its design in a Western country may not be responsible for the problems and the failure to make the new science curriculum relevant. These failings may result from the fact that the curriculum was not adapted properly and was not competent to engage the other voices and users of the new curriculum. Or the pedagogy and content of the American curriculum may have been good enough and helpful for Kuwaiti students, but the conditions in Kuwait were not ready for it, or it needed more adaptation.

The Islamic Religion

The findings confirm that most of the respondents agreed that the new science curriculum was not related to the religious culture of Islam and had no lessons or objectives which connected science to religion by citing verses from the Holy

Qur'an or speeches by the Prophet Mohammed (Hadith) in support of the lessons. The teachers mentioned that some lessons could be linked with Islam, in such areas as the four seasons, the evolution of the earth, the human life cycle and the rotation of the planets in space. This is in agreement with Mansour's study (2009), which confirms that it is important for the science curriculum in Muslim countries to be related to Islam and for the science lessons to include some Qur'anic verses and speeches by the Prophet Mohammed, which would support the scientific statements and clarify those scientific facts that are asserted by Islam, making the lessons more approachable and giving confidence to the students.

Therefore, the findings in this study make it plain that the new science curriculum is unrelated to the Islamic religion of the Kuwaiti students and teachers, perhaps because it was designed in the USA and was not specifically intended for export; it shows images of men and women mixing at parties and drinking alcohol, and also of people wearing skimpy clothes. However, such problems were supposed to have been solved in the adaptation phase, this being one of the purposes of the adaptation, according to the reform planners. This endorses the view that the blame may lie in the adaptation and not in the original curriculum.

Failure to relate the new science curriculum to the students' religion in turn possibly produces a feeling of conflict and hence of difficulty and a negative attitude among the students and teachers which has affected the students' attitude to learning science in general. This argument about science and religion is discussed in Dagher, 2009; Dagher & BouJaoude, 2011; Mansour, 2008, 2011; and Reiss, 2008, 2010, which focus on the relationship between science and religion and the importance of taking religion into account when reforming the science curriculum and in teaching science in schools. These studies support the need to relate science to the religion to make the science lessons more approachable, trustworthy and comfortable for the students and thus easier to absorb.

Regarding Islam specifically, some studies advocate relating it to science (Dagher, 2009; Dagher & BouJaoude, 2011; Loo, 2001; Mansour, 2008, 2011; Shaw, 2006). These studies confirm the importance of making the science lessons relevant to students by incorporating Qur'anic verses into some of the science lessons. In this way, the Muslim students will have confidence that the science lesson is not in conflict with their religion – they will trust the lesson. The studies add that there is no conflict between Islam and science and that the Qur'an and Hadith encourage students to learn science, and to research and explore for themselves. In addition, Loo (2001) confirms that Islam in its first few centuries was distinguished by its science and discoveries and that it is important to teach this to students in Islamic countries to encourage them in learning about science, in the interest of exploring and developing their own country.

Comparing these arguments from previous studies of science and religion with the findings from this study, it is clear that one of the reasons for the negative views and attitudes of the teachers of the new science curriculum may be its lack of relevance to Islam. Because it is not made relevant to their Islamic beliefs, and has inappropriate photographic images, they are alienated from it and it is hard to teach this new curriculum successfully.

In contrast, some previous studies (Alexander, 2007 and Dagher & BouJaoude, 2011) discuss the relationship between science and religion and find it varied and complex. They go through a wide range of ways of seeing how to relate the religion to science, such as through conflict, independence and dialogue (Barbour, 1990). Alexander (2007) compares four major models of the relationship between science and religion: conflict, non-overlapping magisteria (NOMA), fusion, and complementarity; concluding that the 'complementarity' model, that is, one of compatibility, is the one that seems the most useful. This is supported by Dagher & BouJaoude (2011), which indicates that the gap between religious views and science is bridged by compatibility. But Reiss (2010) indicates that some students do not accept certain items of scientific knowledge or scientific theory at all, such as the theory of evolution, because it conflicts with their religious beliefs. He emphasises that these views should be respected but suggests that the theory should be taught to all students so that they can understand, but not necessarily accept, the scientific worldview with respect to human origins. Teachers should be sensitive about teaching it in science classes and both curriculum and teacher need to be developed, the latter by receiving continued professional development to take care of such problems. This will help the students "to appreciate the way science is done, the procedures by which scientific knowledge accumulates, the limitations of science and the ways in which scientific knowledge differs from other forms of knowledge" (Reiss, 2010, p.100).

From this argument it is clear that religion and science can be compatible and that making an effort to relate science to religion is important. However, it is not easy and teachers must use caution in doing so in their teaching. Regarding the new science curriculum in Kuwait, it is clear now that relating all the science lessons to Islam would be difficult, but that some science lessons need the support of Qur'anic verses and the speeches of the Prophet Mohamed (Hadith), as far as this is possible. This will enable students to have confidence that the lesson is not in conflict with the holy Qur'an, and will enable them to trust what they are being taught.

As noted above, the problem may not have arisen because the new science curriculum was designed in the West but because it was not adapted well or perhaps because the teachers did not have enough expertise to relate science to Islam. This simply shows how urgently the teachers needed professional development and the new science curriculum needed adaptation in depth; again, involving the teachers in exploring, on the one hand, how scientific content can relate to Islamic religious culture and, on the other hand, exploring how some science lessons, images and examples may conflict with it, and also to discuss useful ways of teaching.

Centralization

The results revealed that all the teachers agreed on the centralized role that the MoE adopts and applies when it deals with schools, such as forbidding changes to its teaching plans and the content and date of exams. This deprives teachers of the chance to diversify their methods of evaluation (practical and written). This constrains teachers and convinces them that they exist to feel they implement orders from above without any participation or involvement in the development of the learning process. In other words, all the difficulties that the teachers face have a negative effect on education and increase the problem instead of solving it. It is important to sort out the problems and grant the teachers more independence, in order to reassure them of their important role in the process and development of education, the progress of which is propelled by their work. Moreover, this is confirmed by many previous studies, such as Dillon (2009), which emphasizes the important role that teachers can play in terms of the success of a curriculum reform when they are given more free space and adequate tools.

Similarly, Shah (2012) specified that a weak curriculum reform can be attributed to the lack of enough well-qualified and skilled technocrats to support the implementation of this process and also of too little money invested to finance and manage the reform, which merely confirms how important the teachers are in the decision making process. But as things stand at present, Alandeom (2012) exposes the fact that the role of teachers in the process of preparing a new curriculum is not taken seriously into consideration and their input when a new curriculum is introduced into schools is deemed critically deficient, because of their ill-defined duties and obligations in the process. The MoE still centralizes its work and excludes teachers from it, not to mention students.

In general, it was clear that the process of reform was a centralized process confined to a group of decision-makers in the MoE. Thus, teachers were surprised by receiving a new curriculum at the beginning of the academic year which was totally different from what they were teaching before the summer break. This sudden change in the curriculum involved none of them. In other words, not informing the teachers had led to this negative attitude of the teachers to the new curriculum.

Orafi and Borg (2009) are convinced that the Libyan Ministry of Education should have involved the teachers in its reforms to ensure that the new material of the curriculum would be adequately supported in the classroom. But its approach exemplified the centralized practices of the Ministry of Education in most Arab countries, which never involve teachers in their decisions. Handler (2010) also pointed out that since the participation of the teachers in curricular development is not seen as essential, a situation emerges in which the process of curriculum reform needs teachers to make good any shortcomings that appear as the result of necessary changes which affect parts of the educational material. This finding is supported by Dillon, who indicates that science teachers do not always have the same views about building a well-formed curriculum for delivery to students or even about the nature of science itself. Thus, the involvement of different teachers in the process of curriculum reform could play an important part in negotiating the common beliefs with regard to the ideal way of conducting the reform (Melville, 2009).

In brief, there are many studies that confirm the need for the participation of teachers, in particular in the process of reforming and developing the curriculum. Moreover, for the period of assessment and evaluation, feedback from the teachers should be taken into consideration by the decision makers and the MoE as a quick response bringing in teachers' advice and experience. This would help to deepen the education process. In fact, since teachers play a key part in the reform and development of the education process, excluding them from participating impedes the very wheel that moves it forward.

CONCLUSION

The above discussion with the results obtained from teachers leads us to conclude that the negative views of the teachers in Kuwait regarding the new curriculum refer to main causes; namely, that they were not involved in the curriculum reforming process or anything related to it, and that the MoE treats them merely as implementers of its intentions, both for the courses and for the exams. In other words, all the above issues lead the teachers to deal with classrooms and students in a rigid and traditional way and make no effort to diversify, because they already lack sufficient tools and time in the classroom and have only weak support from the MoE in terms of tools and equipment.

The other main reasons for the negative attitudes from teachers to the new science curriculum are that it lacks relevance to the needs, culture and religion of Kuwaiti society. Society's needs, religion and culture are seen to be among the most important issues that should be taken into consideration when reforming or implementing a new curriculum, because students will not engage with it unless it is close to all three. It should have been obvious that the Kuwaiti teachers would suspect the new curricula because they were designed in the USA and transferred from an American original which did not suit and was remote from their culture, religion and everyday needs.

The teachers were not well enough supported by the Ministry with the educational tools and equipment required to implement the new curriculum and this limited their ability to vary their methods in delivering the content to the students and simplifying it to their level. In addition, the high number of students in each class put more pressure on the teachers and exhausted them to a point where they had no desire to innovate and be creative in their teaching, which resulted in classrooms of a more traditional and rigid kind.

Finally, the reasons which negatively affected the teachers' views and attitudes to the new science curriculum were that they did not participate in the reform decisions or process and they had to suffer the centralization of the MoE system, the workload, the weaknesses in the adaptation process and the lack of autonomy in their work.

This may explain why science education in Kuwait needs long-term reform and development, not just as a matter of curriculum content but also in terms of developing the pedagogy and teaching skills, improving the school and classroom environment and empowering teachers by decentralizing the working system of the MoE.

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