Science Literacy in Saudi Arabia through Language Analysis of a Secondary School Physics textbook

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A thesis submitted for the degree of PhD (Education)

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18 June 2018
Statement of Originality

I hereby certify that to the best of my knowledge and belief this thesis is my own work and contains no material previously published or written by another person except where due references and acknowledgements are made. It contains no material which has been previously submitted by me for the award of any other degree or diploma in any university or other tertiary institution.

Thesis by Publication

I hereby certify that this thesis is in the form of a series of 4 papers. I have included as part of the thesis a written statement from each co-author, endorsed in writing by the Faculty Assistant Dean (Research Training), attesting to my contribution to any jointly authored papers. (See Appendix A).

Nouf Albadi 18/6/2018
Permission Regarding Copyright

I have obtained all necessary permission from the copyright owners of my published work such that use of this published work in my thesis is in line with copyright policies of the relevant journals.

Nouf Albadi 18/6/2018
Dedication

To my husband,
my parents, my mother and father in law
for their invocations, prayers and never-ending support.

To my lovely kids
Sadeem and Abdulmohsen
for their patience and endorsement during my study journey.

For my sisters and brothers
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<td>Analysis of Variance</td>
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<td>DLI</td>
<td>Defence language Institute Arabic corpus</td>
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<td>ESP</td>
<td>English for Specific Purposes</td>
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<td>GAT</td>
<td>General Aptitude Test</td>
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<td>KSA</td>
<td>Kingdom of Saudi Arabia</td>
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<td>LSP</td>
<td>Language for Specific Purposes</td>
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<td>M</td>
<td>Mean</td>
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<td>MADA</td>
<td>Morphological Analysis and Disambiguation for Arabic</td>
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<td>MENA</td>
<td>Middle East and North Africa</td>
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<td>ML</td>
<td>Machine Learning</td>
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<td>MoE</td>
<td>Ministry of Education</td>
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<td>MSA</td>
<td>Modern Standard Arabic</td>
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<td>Number of participants</td>
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<td>NLP</td>
<td>Natural Language Processing</td>
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<td>R</td>
<td>Pearson product-moment correlation coefficient</td>
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<td>SAAT</td>
<td>Scholastic Achievement Admission Test</td>
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<td>SD</td>
<td>Standard Deviation</td>
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<td>SVO</td>
<td>Subject –Verb-Object</td>
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<td>TiMBL</td>
<td>Tilburg Memory Based Learning</td>
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<td>VSO</td>
<td>Verb Subject - Object</td>
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### Additional Notes

**Capital letters** are used when referring to a designated subject in the Saudi school curriculum, such as Physics, Chemistry; but not for broader reference to physics, education, literacy and so on. Capitals are also used for year levels (Year 9, Year 10) but not for primary, intermediate or high school. Lower case is used in all mentions of cloze test procedure, in keeping with the Macquarie Dictionary as the Australian standard, although many other sources capitalise or italicise ‘cloze’ to minimise confusion with ‘close’. Standard Australian spelling has been used (e.g. analyse, organise) except where an original source uses the American forms.

**Attributive nouns** are used when discussing overall patterns and trends (e.g. student achievement, teacher input), while possessive forms are used for attributes or possessions of specified individuals or groups (e.g. a student’s self-confidence, teachers’ guides, individual learners’ language abilities).
Abstract

Scientific language is an essential component of science education. Secondary schooling shapes student thinking and provides a gateway to future engagement; and it is there that student interest in science grows or diminishes. Reading science textbooks is an important tool by which students gain access to scientific knowledge. While there is an extensive body of research on language and learning with science textbooks written in English, there is less work in contexts where other languages provide the medium of instruction. Saudi Arabia is one such context.

Modern standard Arabic is used in Saudi school textbooks, and Saudi science education has experienced enormous change over the past decade. This study particularly focused on the current mandatory Saudi Year 10 Physics textbook. A mixed method approach was used to: examine approaches to assessing text readability; gather expert opinions of relative text difficulty; identify specific student difficulties with the language of their Physics textbook; and, ascertain teacher and student response to recent changes in science curriculum and delivery. A review of the existing literature found gaps in the research that guided the formulation of the research questions, which were dealt with in four published articles and subsequent synthesis.

This study revealed that expert readers of Arabic rated passages from science textbooks as harder to read than other text and that the physics passages appeared to be most difficult. Participating Year 10 Saudi students had greater difficulty in accessing their physics textbook than comparable English speakers accessing similar texts and those difficulties could be linked to specific language features. Year 10 Physics teachers agreed that applying the new teaching methods required by curriculum change was difficult but both they and their students held a variety of views about the textbook and other implementation issues.

These findings suggest: that the written language style of the Physics textbook should be made more accessible; that specific language features associated with learner reading difficulty should be addressed more directly; and that, the components of recent changes in Saudi science education should be more closely aligned.
Chapter 1 : Introduction
This opening chapter briefly outlines the purposes and concerns of this study, including its origins and the background to the questions it poses. The structure of the thesis is then explained. As this research is presented in the form of a thesis by publication, the four chapters that consist of published papers are placed in their context within the structure of the full research study, and the body of knowledge to which it seeks to contribute. These four publications are organised according to the logical order imposed by the research questions.

1.1 What prompted this research: A personal reflection
A flashback to my time at secondary school in Jeddah city in Saudi Arabia will serve as the starting point of this study. When I was in Year 10, I was keen to have separate science courses, as my older sister did. Although the concepts introduced in the Physics class were very hard to understand, I liked the class very much. The Physics teacher used to explain the lessons using classic Arabic simultaneously with her regional dialect. Usually, during the class time, I understood what the Physics teacher was teaching, but as soon as I started doing the Physics homework, I struggled. I will never forget the moment when the teacher asked me to stand up and explain the Calorimeter experiment. I was speechless; I could not re-explain the experiment, although I knew it very well. I tried to explain using my colloquial language because I could not remember how to say it clearly in the formal language of Modern Standard Arabic (MSA). My classmates started to laugh at me, I felt embarrassed, and the teacher just stood and stared at me without any reaction or any intention of helping. In Years 11 and 12, I chose the scientific stream which included Physics subjects, and I preferred Physics to Chemistry and Biology. Later when
I had graduated from high school, I joined the College of Education and studied Applied Physics because I loved this subject, despite not having had any encouragement from my teacher. In the Year 3, I was sent to intermediate school to practice teaching a science subject for about a day every week, and at the end of the term, I spent three weeks at that school. Then in the Year 4, we completed the training course for teaching Year 10 Physics. I was encouraged and motivated by the award of a High Distinction in teaching both courses.

In 2008, I arrived in Australia with my family to do my Master’s degree in Science Education. One of the courses that I studied was literacy across the curriculum, which focuses on the specialist language used in school textbooks. That course, however, took me back to Year 10 and the time I was required to explain that experiment. The course allowed me to identify language problems which might occur in science classes. I now understand the importance of the language spoken by teachers inside their classrooms and how it influences their students’ understanding. Moreover, that course was the real motivation to start my Ph.D. research and deeply explore the language used in the physics textbooks, as well as the language used by teachers inside the classrooms in Saudi schools.

In order to begin my research journey, it was essential that I explore first the meaning of the Arabic equivalent of the word ‘literacy’, since this concept is fundamental to the investigation. ‘Literacy’ in Arabic is usually translated as Knowledge of reading and writing, which literally means ‘eradication of illiteracy’ which is obviously somewhat different from the meaning of ‘literacy’ in English. An initial search of the research literature using the keywords ‘Arabic literacy’ found only those studies that were centered
on the eradication of illiteracy, which was not my research focus. Therefore, I changed the keywords to the terms ‘learning Science’, ‘difficulties in learning Science’, and ‘Arab Science education’. These terms produced a variety of topics focused on science education in the Arab world and in the Arabic language.

I was searching for previous studies which specifically focused on the use of the cloze test procedure to measure readability in Arabic language texts. Most of the articles that I found were timeworn and had been completed in American universities, but these were a good basis to begin my literature review, because they focused on the readability of Arabic textbooks. Most of studies published in English concerned readability of Arabic language text for non-native speakers, or ways of computing such readability. Other research articles were concerned with the measurement of text readability for native speakers of Arabic. Most of these had been conducted in Arab countries, including Saudi Arabia, and were written in Arabic but not widely published. The lack of an Arabic research database made it difficult to locate relevant articles, so I began visiting individual university websites in an attempt to find some of these studies. A number of university websites provided information about relevant research but the studies listed were not always available. I contacted the authors whose responses varied from being very helpful to a lack of response to my emails. Consequently, I travelled to Riyadh to King Fahad Library which includes all research theses conducted in Saudi universities. The library’s supervisors informed me that all those completed in Saudi universities must send a copy to the library and suggested that another effective way to search Arabic articles was to use the Saudi Digital library. This data base was a treasure as it allowed me to locate most of the studies conducted in Arab countries and add them to my list of literature.
This enabled me to confirm that the type of analysis for science textbooks (physics) that I was interested in had not previously been investigated in the available research literature in Arabic, and gave me hope that my study could contribute something new and potentially valuable to the teaching of science in schools where Arabic is the language of instruction.

1.2 Background of the study

Science courses are an essential component in all levels of the education process throughout the world. As scientific knowledge has grown and developed, the number and complexity of scientific terms and problem-solving methods have greatly increased, posing ever greater challenges to the teaching and learning of science, for both primary and high school students and their teachers.

Secondary education in English-speaking countries has largely regarded science as a practical subject, and, rightly so, for science is partly empirical. However, for many pupils the greatest obstacle in learning science is its specialist language, and gaining control of that specialist style may be their greatest achievement. One of the important features of science in English is the richness of the words and terms it uses (Wellington & Osborne, 2001). Many science teachers underestimate the difficulty of texts that they expect their classes to read (Herman & Wardrip, 2012). There seem to be similar issues in teaching and learning science in the Arabic language. In Saudi Arabia where this study was conducted, science education has concentrated on bolstering effective strategies in teaching and learning the practical aspects of science, while relatively little research has focused on the language used in Saudi science classes, or indeed any science classes where Arabic is the medium language of instruction.
The study reported here has focused on science at the secondary stage of schooling. Secondary school is the last stage of school education. Students in Saudi Arabia are eligible to start university after they have been awarded the Secondary School Certificate. This certificate is awarded for studies completed in Years 10, 11, and 12 with students aged between 15 and 18 years (Al-Sadan, 2000). The final year is considered particularly important, as it forms the basis for higher education (Al-Rehaly, 2012).

1.3 Statement of the research problem

Most teachers make at least some effort to adjust their language to the level of their students’ understanding, by using an intermediate level or style of language that falls somewhere between the formal register of the subject they teach, and the informal vernacular language that their students bring with them to school. They recognise that students have different levels of ability when working to understand complex language. Teachers rely on both verbal and non-verbal communication methods; for example, the use of gesture, in the quest for good ways to deliver knowledge that is substantially dependent on the teacher’s qualifications and skills. The modernisation of education in Saudi Arabia has included recent curriculum changes aimed at strengthening the practical orientation in classes where science was previously taught mainly through memorisation and recall.

Modern Standard Arabic has developed from Classical Arabic and, although it is the standard form of the Arabic language, it has been mainly restricted to formal use in books, newspapers, curriculum documents and some television programs. Therefore, many people have considerable difficulty in understanding sentences and words that they read because of their weak background in formal Arabic. This reading challenge can be clearly
seen in the educational performance of younger generations, discussed below. A further complication is that many technical and other terms in science textbooks are either drawn from the contemporary, dialect or borrowed from other languages and so they may well be incomprehensible to the students who are expected to read them. In an overview of the quality of education in MENA (the Middle East and North Africa) countries, Bouhlila (2011) used data from the 2007 TIMSS (Trends in International Mathematics and Science Study) data to address the question of low achievement in the MENA region, and suggested that one cause may be that the native language of students is not taught in school. The many local and regional dialects used by both students and teachers may slow down students’ performance in the standard language of formal education.

Formal Arabic language will sound unfamiliar to students in their first grade as there would not have been time to form part of their spoken language repertoire. The phonological systems of dialects in Saudi Arabia, and elsewhere throughout the Arab world, vary significantly, leading to differences in the sounds within words, and differences in which written letters correspond to which sounds, depending on the dialect of the person reading. In dialects where sounds have merged, readers may have to contend with more than one letter for a single sound (Nedwick et al., 2011). Morphological and syntactic structures, that is, the patterns from which words and sentences are constructed, also vary markedly between the classical and modern varieties of Arabic, and the many regional spoken forms of the language. This makes design of an effective policy to overcome the difficulties of learning and reading the classical or standard language very complex, since teachers often use the divergent spoken language to explain ideas and concepts in ways that their students can understand. This suggests that the time devoted to teaching language across the curriculum should be increased and that the manner of
teaching the language be reconsidered. It is from these issues that the fundamental questions for this research have arisen, as further explained in the following three chapters on the study’s context, literature review, and methodological design.

1.4 Significance of the study

This study is intended to fill a gap in research into the impact of specialist language on student achievement in science, with specific reference to Arabic language science education. Issues of communication in science classes ranked as the most frequent topic among the 2294 articles analysed as part of a ten year review of the key research journals in science education (O’Toole, Freestone, McKoy & Duckworth, 2018) but these issues have not received the same attention in research published in Arabic. The recent changes in Saudi Arabia’s science curriculum involve the use of foreign languages (chiefly English) in the mandatory science textbooks, and the use of an identifiable variety of formal Arabic, both of which might be expected to contribute to student difficulties in understanding science terms and explanations in textbooks. The influence of students’ dialects on their ability to learn Physics will also be addressed. This research was conducted in the Saudi Ministry of Education secondary schools in two cities in Saudi Arabia. The teaching and learning environment is expected to differ from one city to another and from cities as compared to villages or towns. Misunderstanding of the nature and origins of difficulties with specialist language by teachers and students may lead to the adoption of ineffective remedial attempts. It is hoped that this study can point the way toward better understanding of the language used in Saudi secondary school Physics instruction, and thus provide a sounder basis for policy and practice in science education.
1.5 Research questions

The central question that this study sought to investigate is whether there are features of instructional text in Arabic that pose difficulties for learners of physics, and if so, can the problematic language features be pinpointed through systematic analysis of learner responses to a sample of such text. This overarching question led to the following more specific questions for detailed investigation.

The next three chapters describe the basis for these research questions by: explaining the current position of science, and specifically physics, within the Saudi education system; outlining what is already known from relevant research literature on the readability of Arabic instructional text; and, stating the methodology which this study used to seek answers to each of these questions.

The four central chapters of this thesis comprise published papers that represent: a conceptual trajectory from the perceived difficulty of various types of text that Saudi students might be expected to read; connections between those difficulties and patterns emerging from research into scientific English; the actual pattern of Saudi student difficulty with physics text; and, the attitudinal and institutional context within which those difficulties are experienced. These four papers address the following research questions.
1. Do text samples drawn from textbooks for a range of Saudi Year 10 subjects differ in readability?

2. Do experts in Arabic language rate Year 10 Saudi science text as relatively hard for students to read?

**Difficulties of Saudi students with their Physics textbook**

3. Do some Saudi students have trouble in reading a mandatory science textbook?

4. Does a close linguistic analysis of Saudi students’ replacement of regular deletions from an authentic Physics text reveal a pattern of language difficulty?

5. Does any such pattern match existing data to the problems faced by English-speaking students with the language of their science books?

**Background and attitudes**

6. How do prior knowledge, language variety and parental education influence student performance when reading?

7. What are the teachers’ and learners’ perceptions of the latest Saudi science education reform with specific relation to Physics, particularly in terms of the style of written language in the textbook and of the new teaching strategies that are required?
1.6 Thesis structure

The investigation on which this thesis is based incorporated an online survey of expert readers of Arabic to ascertain their perceptions of the relative difficulty of Arabic text from different sources and a pilot study of the difficulty of a sample of Physics text for a small group of Year 10 students. This was followed by a more substantial study of student difficulties with a sample of Physics text that had also formed part of the on-line survey and an investigation of student and teacher attitudes to the text from which it was drawn, and their Physics classes in general.

The thesis is presented as a thesis by publication, where four initial explanatory chapters provide the foundation of four published articles reporting the study’s findings in relation to the research questions. The published articles have been slightly edited to make the entire thesis more coherent. These articles are followed by analysis of student survey results and identification of any relationship between student cloze test results and questionnaire responses. This leads into broad discussion of the results and suggestion of plausible conclusions from this investigation. The chapters are organised as follows:

Chapter 1:  *Introduction.*

The general background, aims, research questions, and structure of the study.

Chapter 2:  *Study Context.*

A detailed account of relevant aspects of the education system in Saudi Arabia, the position of science education within it, and the nature of issues that this study addresses.

Chapter 3:  *Literature review.*

The body of established knowledge relevant to the study, and details of prior research that guided its development and methods. This review encompasses all of the literature referred to more briefly in each of the published articles.
Chapter 4:  *Methodology.*

The research paradigm and the quantitative and qualitative methods that were used to seek answers to each of the research questions.

Chapter 5:  *Teacher perceived readability of Saudi school texts.*

This published quantitative paper reports on findings from the on-line survey, with reference to Research Questions 1 and 2.

Chapter 6:  *A preliminary study of the technical use of Arabic in Saudi secondary Physics classes.*

This published quantitative paper reports on findings from the pilot study, with reference to Research Questions 3, 4 and 5.

Chapter 7:  *Reading difficulties and language features in an Arabic Physics textbook.*

This published quantitative paper presents a fuller account of findings regarding Questions 4 and 6.

Chapter 8:  *Recent reforms in Saudi secondary science education: Teacher and student perceptions.*

This published mixed method paper presents findings about teacher and student perceptions of the mandatory Physics textbook, with reference to Research Question 7, and points toward some policy implications.

Chapter 9:  *Student views of Saudi Physics.*

This unpublished chapter presents a fuller analysis of the results of the student survey, with particular reference to Research Questions 6 and 7.

Chapter 10:  *Discussion and Conclusion and implication.*

This final chapter links the results from each of the separate chapters above, giving a unified view of the findings on each of the research questions and of the study as a whole. Then the chapter presents the conclusions and the implications from the entire study.
Chapter 2: Study Context

The purpose of this chapter is to provide an overview of science education in Saudi Arabia and within its education system, which were the context and location of this study. Some background on Saudi Arabia is provided first, to familiarise the reader with the socioeconomic and sociocultural factors operating within the research context. A thorough description of Saudi education with a focus on science education in secondary schooling is then offered. The detail provided in this chapter will be of special interest when the final chapters of the thesis are reached.

2.1 Science in Saudi Arabian national life

Saudi Arabia is a monarchy led by the Al-Saud family (Baki, 2004). The country was unified in 1933 by King Abdul Aziz, from whom the present King is descended. The Kingdom of Saudi Arabia is the largest country in the Middle East (C. I. A., 2013). It is located in the middle of the Arabian Peninsula and is bordered to the west by the Red Sea, to the north by Jordan, Iraq, and Kuwait, to the east by the Arabian Gulf, to the southeast by Qatar, the United Arab Emirates and Oman and by the Republic of Yemen to the south (Al-Alwani, 2005). The Kingdom of Saudi Arabia is the 14th largest country in the world with an area of more than two million square kilometres. Moreover, it is the second largest OPEC Member Country. The population of Saudi Arabia is over 32 million, with more than seven million people living in Riyadh which is the capital city. Arabic is the official language of the country.

The economy of Saudi Arabia depends on oil which was discovered in the 1930s (Siddiqui, 1998). The country is classified as one of the biggest oil producers and exporters in the world (Al-Fawaz, Hilal, & Al-Ghannam, 2014). Saudi Arabia owns 18%
of the planet’s confirmed oil reserves and is the largest exporter of oil. Apart from petroleum, the Kingdom has other natural resources, including natural gas, iron ore, gold, and copper. In March 2017, the Saudis reported that they had significantly lowered their daily production to 10.01 million barrels a day. Saudi Arabia is a founding member of OPEC (C. I. A., 2013; OPEC, 2017). However, the Government is seeking alternative energy sources such as solar and more natural gas (C. I. A., 2013). This presents an opportunity for greater diversification in the resources as well as stimulation of the economy, along with growth in science and technology, with the aim of sustainable future economic growth (Yusuf, 2014).

In technology, the new Saudi vision aims to not only increase its investments in the digital economy, but to lead it. It also intends to localise the oil and gas sector. The announced creation of a new city dedicated to energy will double Saudi gas production, as well as establishing a national gas distribution network. The King Abdullah Sustainable City is considered to be the new home for the atomic and renewable energy sector in the country, and the nucleus of the academic, research and development sector. The intended city will include 16 nuclear reactors with a budget of US $80 billion in the next two decades (King Abdullah City for Atomic and Renewable Energy, 2017).

In April, 2016 The Custodian of the Two Holy Mosques, King Salman Bin Abdul-Aziz, approved a new policy initiative entitled Vision 2030 for Saudi Arabia. Vision 2030 is a highly significant document, drafted by the Council of Economic and Development Affairs as a new start for a bright future for a Saudi Arabia less dependent on oil (Vision 2030, 2017). It declares the intention to transform the Saudi economy by decreasing unemployment by 6.1 % percent (Trading Economics, 2018).
One of the *Vision 2030* goals is to distribute Saudi defence industries among many different industrial sectors, such as information technology and communications, which will reduce military spending and create more job opportunities for Saudi citizens. In Saudi Arabia, the current national defence sector is limited to just seven companies and two research centres. The *Vision 2030*’s aim is to localise more than 50% of military equipment spending by 2030. It will focus on increased training for its employees and the development of much more specialised and integrated industrial complexes (*Vision 2030*, 2017).

The religion of Islam is a key cultural factor in all aspects of Saudi national life. Saudi Arabia is an Islamic kingdom and is the location of the holiest places of Islam. The Arabic language is both the national language, and the language of the holy book *Quran* which is the main source of Islamic legislation and faith. The holy book *Quran* was revealed to the prophet Mohammed (Peace Be Upon Him) in the 6th century AD. *Hadith* is the second source of Islamic teaching, consisting of what Prophet Mohammed was saying and what he taught to his followers. Islam is not just a religious path but an entire way of life, and it provides principles to guide all aspects of life in Saudi society (Abbas, 2009; Montagu, 2010). Islamic doctrines emphasise the values of family and of respect for parents, family members, seniors, neighbours, charity for the poor people, respect for teachers, and full acceptance of other people (Mostafa, 2006).

Women have played an active part in the Islamic community since the early days of Islam. The first believer in Prophet Mohammed (Peace Be Upon Him) was Khadija who was an independent entrepreneur (Reda & Hamdan, 2015). In a family both parents guide their children to follow Islamic values through the children’s lives. Islamic women play the
paramount role in their children’s upbringing (Nather, 2014). Islam upholds justice and guarantees the rights of women (Mostafa, 2006).

In the present day, women are collaborating in the renaissance of Saudi Arabia. Women now occupy prominent positions in Saudi Arabia. The number of women employed in both governmental and non-governmental jobs continues to increase. They are employed in areas such as teaching, health, companies, banking, and the media (Nather, 2014).

More than 50 percent of Saudi university graduates are female; one of the plans of the Vision 2030 is to continue developing their talents and their productive capabilities. Another important goal is empowerment of women by increasing their workforce participation from 22% to 30%. According to the Ministry of Foreign Affairs’ report in October 2017, the number of women studying abroad is more than 35 000; the report also says that there are 30 000 business women with combined investment assets of around $82 billion (@KSAMOFA, 2017).

The Saudi Vision 2030 aims to build the best future for the country. One of the pillars on which it relies is to build on Saudi Arabia’s leading role as the heart of the Arab and Islamic worlds. The Kingdom intends to create a more varied and sustainable economy, which will allow the country to benefit from its strategic location for international trade connecting Africa, Asia and Europe. It aims to reduce its dependency on oil and, by reducing the number of non-Saudi workers in all sectors, to create millions of job opportunities for young Saudi men and women. There are currently more than 10 million guest workers from many different countries. The Saudi Government aims to continue investing in both education and training in order that young men and women are prepared for these jobs.
Science and science education are obviously of great importance in implementing such a vision. The first word that was revealed to the Prophet Mohammed was ‘Iqra’ which means ‘read’. While this is an instruction to believers to read and recite the holy book itself, it is also understood as a broader injunction to read in search of knowledge and learning. Many verses in the holy book of Islam, Quran, urge people to learn and search for knowledge. Islamic nations today agree on the importance of learning science. In the golden era of Islam, Islamic scholars, such as Ibn Rushd, Ibn Alhaytham, and Abu Baker Alrazi founded and led research on the most critical issues in then-contemporary science (Falagas, Zarkadoulia, & Samonis, 2006). In mathematics, around 830 AD Al-Khwarizmi worked on the quadratic equation which became a most important part in mathematics, which in Arabic is still called al-Jabr. Arabic and Islamic scientists developed the connection between mathematics and astronomy (Alexakos & Antoine, 2005). As Arabic and Islamic philosophers were such pioneers of scientific scholarship, their inventions and theories still form the basis of mathematics and sciences (Endress, 2002).

European scholars did not have the chance to go to Spain and learn Arabic in order to read texts which had been written in Arabic or translated into that language from Greek. In Western Europe, translation of texts on different disciplines such as medicine and philosophy from Arabic to Latin gave great opportunity to Westerners to access to the rich libraries of the Islamic world. Gerard of Cremona, a famous translator of Arabic texts, translated works by most of the famous Muslim scholars (such as, Ibn Rushd and Ibn Sina), playing a vital role in providing European access to different branches of scientific knowledge, such as the physical sciences, medicine and astronomy (Versteegh, 2014).
Over the past 150 years, international progress in science and technology has expanded the horizons of human ability and facilitated essential transformations to our quality of life. Science, also, has improved access to modern forms of energy, evolving from steam-engines in trains to nuclear power plants. Basic and applied sciences, supported by new technology, make life much easier. Science has become the key to understanding the social and natural phenomena around us. Science has changed and improved during the centuries, so reforming science education has become essential to increase science literacy of countries around the world (Brooks, 2008). This is widely accepted in Saudi Arabia, where the general view is that seeking knowledge is encouraged in Islamic culture. Most of the Saudi science curriculum is considered to be not only compatible with but to have been derived from the tenets of the Quran (Al-Sulaimani, 2010). Such historical and religious imperatives reinforce the importance of science in Saudi secondary schools.

Successive Saudi Arabian Governments have believed in the importance of learning science, which has led the Government to increase the number of universities from seven to 22 in different parts of the country to allow for equal opportunities for people from both rural and urban areas. In 2006 King Abdullah announced a new project which was the establishment of the King Abdullah University of Science and Technology with a cost of $10 billion from his own money. On September 23, 2009, which is the Saudi national day, King Abdullah opened the University in a grand ceremony in the presence of presidents from other countries (King Abdullah University of Science and Technology, 2017). This University offers Master’s and Doctoral degrees with the budget of $10 million dedicated to free scholarships and construction of buildings. The aim of this university is to become the Harvard and Yale of the Middle East (Krieger, 2007). This
University has become the third wealthiest university in the world (Nonprofit colleges online, 2018).

2.2 The Saudi education system

2.2.1 Historical roots

Education in the Kingdom of Saudi Arabia has undergone considerable change since unification in 1932 (Al-Harthi, Al-Asmari, Al-Ghamdi, Al-Qurashi, & Kabrah, 2011). The previous, traditional system, known as ‘Katateeb’, was based almost exclusively on Islamic studies (Hamdan, 2005). In 1925, The Directorate of Knowledge was established to oversee the education of boys in Saudi Arabia. At that time the Directorate of Knowledge ran only four schools but the number increased to more than 3000. Then in 1953 the Ministry of Education was established to replace the Directorate of Knowledge (Ministry of Education, 2017). This was one of the important educational developments in Saudi Arabia.

While the Ministry of Education was responsible for boys’ education, the education of girls was under ‘The General Presidency for Girls’ Education’ which was established in 1960 (Sadaawi, 2010). This led to the establishment of the first public school for girls (Baki, 2004; Hamdan, 2005). Then in 2003 the responsibility for girls’ schools was transferred to the Ministry of Education (Sadaawi, 2010).

Since the establishment of the Ministry of Education in 1953 all stages of education, including higher education, have been free for everyone in Saudi Arabia (Wahab, 1970). Separate institutions continue to be maintained for each gender (Al-Amri, 2011).
The first secondary school (for boys) was established in 1926, with the curriculum composed only of Arabic and religious studies. Later Science, Mathematics, and English were included in the curriculum. When secondary schools were established, there were five years in the program, but in 1958 this was reduced to three years (Abdulsalam, 2009). Non-government schools began to appear in the 1970s. A mixed system has emerged, with the majority of children enrolled in the government sector (Ministry of Education, 2017).

Arabic language remains the medium of instruction in Saudi schools. This is significant because the language exists both in a formal written form (based on the language of the *Quran*) and in many national, regional and local spoken forms. The local dialects can differ significantly from the prestige dialect of the religious text.

The Ministry of Higher Education, which was established in 1975 (Al-Alwani, 2005), encompasses 28 universities, as well as different institutions, colleges and other providers of educational training in various disciplines (Makhdoom, 2012). In 1960 the Institute of Education Administration was established, and then in 1980, the General Organisation for Technical and Vocational Training was created. All these institutes are operated separately (Al-Alwani, 2005). In 2015, both ministries of education and the higher education ministry were merged into one organisation which is called the Ministry of Education (Ministry of Education, 2018).

2.2.2 The contemporary situation

Schooling in Saudi Arabia now begins with kindergarten, followed by 12 years of schooling organised into three levels: six years in elementary, three years in intermediate
and three years in secondary level (Al-Robaee, 2004). General Science is taught from one textbook at elementary and intermediate levels and then in the secondary level, science is studied as separate subjects: Chemistry, Biology and Physics. Students in the first secondary grade (15-16 years old) are required to study literary, scientific, and administrative subjects but in the next grade (16-17 years old), they are asked to select the scientific, administrative or the literary stream. All students who choose the scientific stream study Biology, Chemistry, Physics, and Mathematics.

Before the formal public school for girls was established in 1960, some wealthy families provided private teachers to teach their girls. Lower income families could send their daughters to informal classes, Kutab, to learn Quran and religious studies (Al-Rawaf & Simmons, 1991). Islamic people from many parts of the world come to Mecca to perform the Hajj (mandatory pilgrimage). In 1941 the first formal public school for girls, the Madrasat AlBanat AlAhliah, was established in Mecca by an immigrant Indonesian man who remained in Saudi Arabia after performing the Hajj. Afterward, there were some private girls’ schools created by Saudis in Mecca (1947), Jeddah (1956) and Riyadh (1955). In 1959 King Saud stated in a formal speech that girls must have the opportunity for an education (Al-Rawaf & Simmons, 1991). In 2009, King Abdullah decided to empower women by designating Dr. Noura al-Fayez to be the education leader of girls’ affairs in the Ministry of Education (F. Al-Harbi, 2014).

King Abdullah bin Abdul-Aziz announced a project for the Development of Public Education between the period 2004 to 2014 (F. Al-Harbi, 2014; Nather, 2014). The program’s ten-year plan aimed to develop curricula, teacher skills, enhance student learning skills and develop their talents and identities, and improve the educational
environment and prepare it for the integration of technology (Al-Suwayied, 2017). This
development had profound implications for the present investigation.

In 2006, the Tat’weer Company for Educational Services, a company wholly owned by
the Saudi Government, accepted the responsibility to implement the King Abdullah
project. In regard to curriculum development, this company established four projects for
comprehensive curriculum development of Science, Mathematics, and English language.
Other projects include a system of credit hours for secondary schools, which is now
operating in all secondary schools based on optional courses each year. Another project
emphasises teacher training, and establishment of a standard test to measure the
qualifications for in-service and pre-service teachers (Al-Suwayied, 2017, p. 155).

In 2013 the Ministry of the Council established the Public Education Evaluation
Commission in the capital city of Saudi Arabia, Riyadh (Education Evaluation
Commission, 2017a). This commission is an independent department with its own budget
and administration and is responsible for evaluation of both public and private schools.
Some of its strategies focus on developing:

1- An evaluation system to ensure the quality of public education.

2- Advanced standards for public education stages, for measuring performance
efficiency at the institutional and program levels.

3- Implementing standardised national tests at every educational stage.

4- Curriculum standards and determining knowledge and skills to be acquired by
students at each stage (Education Evaluation Commission, 2017b).
The Saudi Vision 2030 contains eight strategies for development of the Ministry of Education as one of the main pillars for a modern society. These strategies, as listed on the Vision 2030 website, are to:

1- Provide education services for all student levels.

2- Improve recruitment, training, and development of teachers.

3- Improve the learning environment to stimulate creativity and innovation.

4- Improve curricula and teaching methods.

5- Improve students’ values and core skills.

6- Enhance the educational system’s capability to address national development requirements and to meet labour market demand.

7- Develop creative financing methods and improve the educational system’s financial efficiency.

8- Increase private sector participation in the education sector (Vision 2030, 2017).

In conjunction with this, as part of a media broadcast, the Minster of Education, Dr. Ahmed Al-Issa, stated that:

The plan focuses on a comprehensive package to develop the educational environment and keeps up with other development plans. At the forefront, there are plans for comprehensive modernisation of the curriculum and teachers’ performance and the improvement of the school environment to stimulate development and creativity. The plan will focus on developing teaching methods and improving the capabilities of
teachers. Women teachers, many of whom live and work in remote areas, will receive more government assistance (Arabiya, 2016).

These successive developments in the Saudi education system represent an ever-increasing emphasis on improvement of educational standards and on improving the status of women and girls in and through education. While gender segregation between male and female education is still the social norm, education policy and funding aims for full equality between the two systems.

2.3 Science education in Saudi secondary schools

Knowledge in science is intended to help people to understand the natural and social environment around them, which implies that the essential element of science teaching is the explanation of the nature of phenomena and how the students come to understand them in their daily life (Subbarini & Al-shorman, 2002).

Secondary school in Saudi Arabia consists of three years. Science courses in secondary school are divided into three courses: Physics, Chemistry, and Biology. In Year 1 of secondary school, there are two periods each of Physics, Chemistry and Biology courses a week, while Mathematics has four class periods each week. Years 2 and 3 have four courses for each science subject per week. The secondary school day usually consists of six to seven lessons in different subjects with five minutes between them, to allow the teachers time to move to the next class. After the third lesson, there is a break about of 40 minutes with another break of about 15 minutes for a prayer break (Al-Hazmi, 2010). The school day starts at 7:45 am and ends at 12:30 pm in the summer. In the winter the day starts at 7:15 ending at 1:30 (Al-Kahtani, 2015).
The secondary school now has two systems of learning. One of the King Abdullah projects for the comprehensive curriculum development in 2004 introduced the new secondary school system called the \textit{credit hours system}. The secondary school period is the last stage in the general education and the preparation for the higher education and labour market. The \textit{credit hours system} aims to make a qualitative leap in secondary education, in terms of its objectives, structures, methods, and contents. This system was in a limited number of schools with most schools following the traditional system called the \textit{annual system}. The credit hours system is similar to the University system, which allows students to choose subjects and the opportunities to withdraw and enrol in a different course.

This system divides each year into two levels (Term 1 and Term 2). Year 10 is called the preparation year, and is similar to the traditional system. In this year students have to study 130 hours with 26 courses and it allows students to choose which course they prefer to study at each level. They can acquire some help from their academic guide as each school provides this service (Al-Kahtani, 2015). These courses are similar to the courses of the traditional system in terms of science subjects. In Years 11 and 12, students have to choose between the Scientific (Physics, Chemistry, and Biology) or Literary tracks. In each of these tracks, students have to complete 60 hours with 12 courses in each of Year 11 and 12. There are additional courses, which are called optional (i.e. elective) courses. Each student should choose a minimum of two courses (10 hours) or maximum five courses (25 hours). These optional courses can be extra courses related to their specialist tracks that they choose, or general courses. The benefits of this system are that when students choose certain subjects they study these subjects at one level. In addition they can speed up their schooling year when they apply in the summer term. This system
reduces the number of subjects and prepares students to focus on limited subjects. Moreover it prepares students for the university system and helps them to learn how to choose their subjects.

The success of this course system has led to the new Tat’weer project for comprehensive curriculum development (Ekhbariyahtv, 2014, Jul 23). In 2014 a royal decree announced that the new system for secondary school called Al-Fasly ‘quarterly system’ would replace the traditional secondary school system (Yearly system), which had operated for the previous 62 years. The aims of the new system are to prepare the students for life, the labour market or to continue their education (Ministry of Education, 2015). This system originally started when students were in Year 10, then progressing to Years 11 and 12 and completing by the end of 2016. During the time of this study data collection occurred during the initial stage of this new system. The Deputy Minister of Education from the Department of Planning and Development announced that 20% of the total of all schools are following the credit hours system, and 80% are in the Al-Fasly quarterly system (Ekhbariyahtv, 2014, Jul 23).

The difference between the quarterly system and the credit hours system is that, in the course system a student is able to choose the subject for each level among groups of courses. In the quarterly system students have to study certain groups of subjects for each level. This new system is different from the previous, traditional one in regards to the number of subjects, tracks chosen, marks scheme and other elements which are detailed as follows:

The new system has reduced the number of subjects from 21 to 14 in Year 10. In the past there were two semesters per year with the grades cumulative for each year (Semester 1
grade + Semester 2 grade = the entire grade for the year). The new system is divided into
two levels per year. Instead of being called ‘semester’ it is now called ‘level’. See Table
2.1.

Table 2.1: Secondary school system

<table>
<thead>
<tr>
<th>Year 10</th>
<th>Year 11</th>
<th>Year 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• semester1 level 1</td>
<td>• semester1 level 3</td>
<td>• semester1 level 5</td>
</tr>
<tr>
<td>• semester2 level 2</td>
<td>• semester2 level 4</td>
<td>• semester2 level 6</td>
</tr>
</tbody>
</table>

In the past, in the traditional system, the students in Year 10 had 21 subjects, which
included both literary and scientific subjects. After that, girls chose between two tracks,
scientific or literary and boys had an extra, Islamic study track. The new system unified
the tracks between girls and boys. Both of the genders have to choose from the scientific,
literary and administrative tracks. Students have to complete the tracks in 35 periods a
week with 12 subjects at each level.

2.3.1 Assessment system for secondary science

There have been many changes in assessments and testing in Saudi education. This
section focuses on the secondary stage assessments with greater emphasis on science
courses. Popham (1995, p. 3) defined educational assessment as “a formal attempt to
determine students’ status on educational variables of interest”. The introduction of the
new quarterly system was accompanied by a new marks scheme, providing for a variety
of assessment methods to allow students to have the advantages of these different sources
and to gain scores from different places. (See Table 2.2).
<table>
<thead>
<tr>
<th>Mark description</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>5 marks</td>
<td>5 marks</td>
<td>5 marks</td>
</tr>
<tr>
<td>Participate in class</td>
<td>5 marks</td>
<td>5 marks</td>
<td>5 marks</td>
</tr>
<tr>
<td>Homework</td>
<td>5 marks</td>
<td>5 marks</td>
<td>5 marks</td>
</tr>
<tr>
<td>Portfolio</td>
<td>5 marks</td>
<td>5 marks</td>
<td>5 marks</td>
</tr>
<tr>
<td>Projects or research</td>
<td>10 marks</td>
<td>10 marks</td>
<td>10 marks</td>
</tr>
<tr>
<td>Midterm exams</td>
<td>15 marks</td>
<td>15 marks</td>
<td>15 marks</td>
</tr>
<tr>
<td>Practical midterm exam</td>
<td>5 marks</td>
<td>5 marks</td>
<td>5 marks</td>
</tr>
<tr>
<td>Final test</td>
<td>40 marks</td>
<td>40 marks</td>
<td>40 marks</td>
</tr>
<tr>
<td>Final practical test</td>
<td>10 marks</td>
<td>10 marks</td>
<td>10 marks</td>
</tr>
<tr>
<td>Cumulative average percentage</td>
<td>25%</td>
<td>35%</td>
<td>40%</td>
</tr>
</tbody>
</table>

The final assessments in the secondary stage have been changing to keep up with the changing demands of education. In the past, assessment was by a school’s internal examination, operated in Years 10 and 11 by the local teachers. In Year 12, students from all regions took national exams prepared by the Ministry of Education. The exam timetable was identical for all schools in Saudi Arabia. Nowadays, the marking scheme for Year 12 is as follows:

1 - The School year has two terms.

2 - 100% is the total mark, divided into 50% for each term.

3 - Each term has three periodic tests providing 30% of the total final marks.
4 - The final exam at the end of each term is worth 70%.

5 - All examinations are performed in writing except the Holy Quran which is an oral exam.

6 - 50% is the minimum pass score of the final score for all subjects (Al-Sadan, 2000).

In 2000 a royal decree announced approval of a decision of the Higher Education Council along with the Council of Ministers, to establish The National Centre for Assessment which is financially independent. The requirements for college admission include exams where the results are used as a standard along with the high school diploma results; those tests are performed according to the following:

A - Exams to assess student abilities and skills (GAT - Graduate Aptitude Test).

B - Exams to assess student educational achievements.

These two national assessments are administered in Year 12. The advantages of these tests are that students can repeat them more than once in a year until they reach the mark that they need for individual universities and departments in which they wish to enrol. Students have to pay test fees commensurate with the costs of running the centre, preparing the exams, and for test entry (National Center for Assessment, 2017). There are complaints from families that it costs them money if their child wants to re-sit the test.

The first test is the graduate aptitude test (GAT). This test is designed for students who aim to enrol in any of the higher education institutions. The test is constructed to measure student abilities in analysis and deduction. This test has two parts; linguistic (verbal) and mathematical (quantitative).
The second test is the educational achievement Scholastic Achievement Admission Test (SAAT). This test is one of the university’s requirements. The aims of this test are to assure that all students gain an equal chance to achieve the higher education target. This test emphasises the main concepts of learning in all secondary school stage courses. It is divided into two parts; one for the students who graduated in the scientific track and the other from the literary path. The percentage of questions constructed from each year is 20% Year 10, 30% Year 11 and 50% Year 12. The scientific test courses include Biology, Chemistry, Physics and Mathematics. In regard to the literary test, the subjects are Islamic study, Arabic grammar, History and Geography (National Center for Assessment, 2017).

Both of these tests have to meet specific criteria set by each higher education institution. These test measurements are not related to secondary school final exam results. Students in secondary school are under pressure to pass the final exams and achieve a high percentage in the different test attempts.

The traditional system was based on final exams, as mentioned above. When students failed in six courses they had to repeat the exams, and if they failed again they had to repeat the whole year. The policy makers believed that this wasted students’ time and increased the costs for the Ministry of Education. Thus, both the credit hours system and Al-Fasly quarterly system aim to reduce costs by allowing students to have a chance to repeat the course in the next level in the credit hours system. The quarterly system gives opportunities for students to repeat the failed course exam in the summer time and if they fail again they can repeat the exams at the beginning of the following year. Both systems follow the standard Saudi national assessment outlined above. These standardised tests guarantee equity of opportunity for all students in the country (Al-Nahdi, 2014).
2.3.2 Teachers and teaching methods

Changes in Saudi secondary schools are intended to overcome barriers whether in school buildings, teacher qualifications or the rigidity of the curriculum and methods (Al-Sonbul, Al-Khateeb, Motwali, & Abdulgawad, 2008). Teachers have been one of the main pillars of educational development and student achievements, in particular when they have a high degree of qualification and are well trained (Al-Nahdi, 2014). In Saudi secondary education, science teachers teach the specific science disciplines: Physics, Chemistry or Biology.

Indeed, teachers play a prominent role in the education process in their capacity to deliver information and knowledge in a professional way in the classroom and thus are essential to the success of the whole learning process (Welmond, 2006). There is local evidence that teacher self-efficacy of teaching style is directly related to students’ achievements in their learning progress (Al-Dakhil, 2015; Al-Shalaan, 2006).

Student respect for teachers is a cultural norm in Saudi classes. In addition, it is incumbent on the students to memorise work and try to avoid any mistakes (Gresham, 2013). This affects their habit of learning as they want to show their teacher that they have memorised the information as opposed to having tried to understand and been motivated by it. This lack of interest in students’ enjoyment of learning has been identified as one of the defects of the education system in Saudi Arabia (Al-Abdulkareem, 2004). Al-Muswary (1993) points out that teacher behaviour in dealing with students can affect their willingness to communicate with their teachers.
Students memorise equations and follow the steps of problem-solving. This remains the common way of teaching methods in science classes (Al-Hadlaq et al., 2009). Such approaches affect students’ enthusiasm and thus, students are just keen to pass the science exam. A regrettable result of state domination of the development of the new curriculum is the tendency for most schools (teachers and students) to continue to focus on memorizing information needed for the exams (Khalil, 2012). The Ministry of Education introduced a standards test in 2001 which contains tools to assess teacher competencies and preparations in different information in subjects according to the necessary skills requirement and professional standards of each subject (Al-Nahdi, 2014; Al-Sadaawi, 2007). This standard test is one of the National Center programs for assessment which was laid out previously.

The Ministry of Education’s report on the period 2000-2004 indicated that the challenge facing the education system was to increase the ability of students to be competitive in the workforce. Thus focusing on the quality teaching of Science and Mathematics by adopting the best learning methods and best practice in teaching was essential in achieving the goals of the new reforms (Sadaawi, 2010).

In 2011 the Ministry of Education announced that 80% of teachers were to undergo an evaluation based on their students’ achievement in the national examination. However, Al-Nahdi (2014) writes that one of the problems facing Saudi Arabia remains the lack of accountability for teacher performance, particularly those in government jobs. Earlier research found inconsistencies in teaching quality, for example, a lack of enthusiasm and poor sense of responsibility (Al-Tayar, 2003). Teaching positions are regarded as being
well paid and secure (Al-Mazrawi, 2014) which can result in reduced motivation for good teaching.

Encouraging teachers to attend workshops and training courses for a fee might increase their receptivity to develop their teaching skills (Al-Nahdi, 2014). However, another study found that teachers reported a mismatch between their needs and what in-service workshops prepare them to do when they return to class. They indicated that some trainers in workshop sessions were deficient in such basic scientific knowledge as force and motion, laboratory use, and chemical bonding (Mansour, Alshamrani, Aldahmash, & Alqudah, 2013).

One of the new reforms in Saudi education is to emphasise the use of ICT in developing the country and in teaching (Al-Zahrani, 2015). Many scholars are interested in both the media and the environment in which teaching occurs. Others are concerned about possible barriers to implementation of the reforms, such as inadequate lab supplements, lack of library resources and ICT equipment, and overcrowding of students in classes (Al-Maghlouth, 2008; Al-Muswary, 1993; Al-Sulaimani, 2010). In a study conducted by Al-Maghlouth (2008), 72% percent of teacher participants believed that using ICT in science lessons would improve students, ability and grades, and encourage them to learn and be more proficient, confirming that ICT is essential for both teachers and students. This concurs with Al-Sulaimani’s (2010) study, which found that three-quarters of his teacher participants reported good experiences in incorporating ICT into their science lessons and Al-Mutairi (2007), who found that students preferred visual learning.

This is despite the fact that less policy attention is given to using ICT in teaching the content of the pre-service teachers’ curriculum (Al-Zahrani, 2015).
Another recent study found that pressure on teachers due to the amount of work that they have to cover (Al-Kahtani, 2015) may be limiting the use of ICT by teachers due to time constraints (Al-Mulhim, 2014). In addition, Al-Kahtani (2016a) observed that another barrier could be a shortage of funding for ICT equipment. Al-Kahtani suggested that a program of training would enhance teachers’ initiative to use ICT in teaching science; and moreover, that education reform would be greatly enhanced by including all people engaged in its implementation, such as teachers and students, in decision-making (Al-Kahtani, 2016a, 2016b).

Students appear to learn more effectively in laboratory lessons (Hart, Mulhall, Berry, Loughran, & Gunstone, 2000; Hofstein & Lunetta, 2004), as they investigate new concepts and explore familiar ones (Trowbridge, Bybee, & Powell, 2000). Moreover, teacher demonstration followed by engagement in the experimental process, allows students to acquire and practis generic learning skills such as observation, measurement, prediction and inference (Zytun, 2008).

2.3.3 Saudi science curriculum

The curriculum is a significant component in the learning process. In Saudi Arabia, the curriculum is mostly represented in the form of textbooks, which are the main resource for both teachers and students. The Ministry of Education produces the textbooks for each semester and these books contain material for lessons, exercises and practical work (Rugh, 2002). These textbooks are written and designed by subject specialists and experts and distributed at no cost to both government and private schools and for teachers and students (Al-Juwaiber, 2009).
The curriculum in Saudi Arabia is defined as the sum of educational experience, derived from course objectives and learning outcomes adopted by the Government. These learning outcomes and objectives are based on content, methodology, educational resources and school activities and are finalised through assessment within the public education sector (Sheikh, 2002). Arabic is the medium of instruction. The primary, intermediate and secondary schools in all regions in Saudi Arabia share the identical curriculum system regarding textbook, evaluation methods and number of lessons (Al-Sadan, 2000).

Curriculum development in Saudi Arabia has been changing rapidly over time. In the past, the General Directorate (now the Ministry of Education) used the curricula and textbooks of Saudi Arabia’s neighbouring countries, such Syria and Egypt, as their first model of education. The Ministry of Education has more recently begun to develop its own curricula in recognition that, in its view “The educational curriculum is a powerful source for a nation since it is the curriculum which can trigger a person’s soul, mind, and body; making each work with maximum effectiveness” (Ministry of Education, n.d.).

When high stakes examinations are based on mandated textbooks, it is essential that textbooks are designed in ways that acknowledge their authority as the predominant source of knowledge and information, critical thinking or any other inquiry (Pingel, 2010).

According to Saouma Boujaoude (2007), the new curriculum in the 21st century should change and keep pace with contemporary changes of curricula developed on the basis of critical thinking. The new reform in Saudi education has seen a shift from policy
preference for teacher-centred traditional teaching to a student-centred approach where critical thinking is integral (Ministry of Education, 2010).

The change process began in 2010 with curriculum reform for Grades 1, 4, 7 and 10. The second stage (2011) targeted Grades 2, 5, 8 and 11 and the third and last stage (2012) focussed on Grades 3, 6, 9, and 12. These curriculum reforms are associated with projects dealing with the Saudi education strategic plan, testing and evaluation, and educational leadership (Ministry of Education, 2010). The new science curriculum was developed in collaboration with the Obeikan Research Development Company (Obeikan Education, 2013). This company reached an agreement with the American publishing company McGraw-Hill to make a translation of mathematics and science textbooks for Grades K-12 (Al-Ghamdi & Al-Salouli, 2012; McGraw-Hill, n.d.). These books were translated and slightly adapted in line with the Saudi educational environment and Saudi culture (Al-Shamrani, 2012).

Even as far back as 1999, Al-Ghanem argued that curriculum reform in science education would also require changing the traditional style of teaching science. The traditional style deterred students’ creativity and critical thinking (Rugh, 2002). However, the Saudi science teachers of today are still following the traditional style (Al-Hammad, 2015). The lack of comprehensive preparation for the reforms has bound the teachers to the traditional style. A study conducted by Gashan (2015) required pre-service teachers studying at the College of Education at King Saud University to explore their knowledge of critical thinking. His findings revealed that the participants had insufficient information about critical thinking. The participants had a positive attitude toward implementing this new learning style; however, they did not have the confidence or the
skills required for this method. This lack of background knowledge in teaching these skills might have an adverse effect on development of students’ critical thinking skills (Al-Lamnakrah, 2013a).

Additionally, Al-Lamnakrah (2013b) and Al-Wadai (2015) stress that Saudi cultural values play an essential part in reforming the curriculum. Both authors explain that the leaders and politicians are regarded as superior and it is considered inappropriate to criticise them. Therefore students might feel awkward if they employ critical thinking skills and actively critique what they are learning from sources which are seen as authoritative. Al-Wadai (2015) revealed another issue; that of the misconception of critical thinking in Saudi society. It is deemed to have a negative meaning due to the absolute power of the political authority which exists in the Saudi community. From his data, Al-Wadai (2015) further clarified that students regard their teachers as impeccable, knowledgeable people. Thus they are unwilling to negotiate and discuss with their teachers unless the teachers introduce the strategies of critical thinking in learning. A similar situation occurred in the United Arab Emirates, where Sonleitner and Khelifa (2005) found that students were not prepared for a learning environment based on critical thinking and problem solving.

The Ministry of Education, represented by the Curricula Department, was solely responsible for the developing of the curriculum and Al-Sadaawi (2007) has pointed to a lack of teacher input into any development of the Saudi curriculum and the lack of training given to science teachers to adapt to new styles of teaching. Many science teachers continue to express frustration that there is no relationship between the required new science curriculum objectives and the capability of the education systems regarding class
size, period time and laboratory supplements (Al-Ghamdi & Al-Salouli, 2012). Al-Hareth and Al-Dighrir (2014) were critical of the fact that teachers were not involved in the reform process. They stated that rather than just receive the information and instruction to achieve curriculum reform, teachers should be involved from the beginning and thus be able to apply the new methods. On the other hand, Al-Nahdi (2014) claims that the reforms in education of Saudi Arabia must include all different aspects in relation to education rather than simply focusing on one area, such as textbooks. He mentions that the Ministry of Saudi Arabia had implemented many reform projects in the past, but that most of the reforms focused solely on textbooks. Another issue raised by Al-Dahmash, Mansour, Al-Shamrani, and Al-Mohi (2016) who analysed the Saudi Science textbook, indicated that neither the Science textbook or the practical textbook were designed to allow for students to employ inquiry skills. The authors suggested the new reform and the policy makers should consider science textbook content. The process of developing a new curriculum may seem too challenging and daunting a task for participating teachers (Bin Salamah, 2001), particularly in a context that has been characterised by central directives.

2.3.4 Language of Saudi science instruction

The new U.S.A.-derived science curricula that have been recently adopted in Saudi Arabia are entirely different from those that they replaced. A McGraw-Hill textbook has been translated and presented in Arabic in MSA but the new definitions and symbols and physics units are written in English. This is clearly visible in Fig. 2.1, a sample page from the Year 10 Physics textbook. The letters and numbers in the formulas are presented in English format (e.g. \( m = 50.0 \text{ kg} \)), with the accompanying explanations in Arabic. Sometimes an English symbol (e.g. \( F \)) is accompanied by an Arabic subscript. Moreover, numbers in English format appear within the Arabic text, as in the first two lines of the
sample page, and Arabic headings (seen in bold on the sample page) are introduced by numbers in English format rather than the normal Arabic numbering. As if this were not confusing enough, recall that the Arabic text is read from left to right, while all English-format numbers and formulas are read from right to left.

Amin (2009) highlights the implication of learning science in a foreign language, such as English, for access to innovation and technology. However, learning science in a mother tongue such as Arabic is made more complicated by the linguistic diversity of spoken varieties of the language, which diverge significantly from each other and from the Modern Standard Arabic used in the textbook. Dagher and BouJaoude (2009) have emphasised the limited research into the language employed in the science textbooks in Arab countries, and recommending further research into the language used in science with the aim of enhancing learning and educational output.

In most considerations of science education, the focus is understandably on the content of what is to be taught and learned, and the whole question of the language of instruction is frequently completely overlooked. Even in languages where there is not as great a divergence between written and spoken forms as there is in Arabic, there is a tendency to overlook the differences between subject-specific registers. The language of science differs significantly in vocabulary and language structures from, for example, the language of literature or of current affairs. As Cummins (2000, p. 55) pointed out, “Different contexts require access to specific registers for adequate or satisfactory functioning”.
In the Saudi context, it has been asserted that the language used in the curriculum of the 21st century should focus on the correctness of the language that leads to powerful meanings and contextual clarity (Al-Qasim & Asiri, 2016). However, the nature of that
language, and what constitutes correctness or contextual clarity in relation to each subject within the curriculum, has remained far too little examined.

2.4 Summary

This chapter began by outlining the importance of science and technology in Saudi Arabia’s national development plans, and pointed to some of the religious and cultural factors that have an influence on science education policy and practice in Saudi Arabia today, including the role and status of women in education and the workforce. An overview of the Saudi education system was presented, tracing its historical background and current policy directions before giving details of the current arrangements for science education in secondary schools in terms of subjects taught, assessment structure, teaching, curriculum and instructional materials. Specific issues relevant to the concerns of this study were highlighted, including issues affecting teaching delivery, curriculum quality, the success of education reforms, and language issues that may have an impact on learning.
Chapter 3: Literature review

3.1 Introduction

The central concern of this study is the comprehensibility of instructional materials for Saudi secondary school Physics students. This opens up a set of interrelated issues in language and science education that needs to be located with reference to theoretical constructs and research findings from linguistics, education, Arabic language, and readability measurement. This review first examines the nature of language in relation to science education. Next, it considers the little that is currently known about Arabic as the language of instruction in Saudi school science. Finally, it analyses the findings from readability research, with particular focus on its applications in Arabic, which forms the background to this study’s methods.

3.2 Language and literacy in science education

Language is a complicated yet necessary system of expression among humans that allows them to communicate their needs and desires with each other (Thomason, 1988). It is based upon a strict set of rules that apparently only humans have the capacity and ability to use. The modern scientific study of the different systems of language is known as linguistics. Linguistic analysis reveals unique characteristics and features of human languages between different geographical locations and their particular social needs according to environmental and cultural factors (Thomason, 2001).

The complexity of human language systems enables a far greater capacity to communicate on a social level than the communication systems in the animal kingdom.
While communication in the animal kingdom is mostly genetic and limited in function (Tomasello, 2008), human language is distinct in terms of being able to use language beyond the immediate context, to reflect on the past and conjecture about the future. Human language has changed over time, through many evolutions, and is constantly changing; in some places evolving into a new language, and elsewhere being subsumed or superseded by other languages. Nowak and Krakauer (1999) state that while language is initially an analogue of sounds only, it has developed into a multilayered grammatical system composed of subsystems as a result of humans needing to find an easy way of being able to communicate information with each other. This multilevel, complex and generative grammatical system is the result of combining sounds into words then using basic grammatical rules to create phrases and sentences, leading to an almost infinite ability to describe or communicate abstract meaning through gestural, verbal, and written expression (Fedurek & Slocombe, 2011).

Grammar plays an essential part in languages as it is through grammar that communication can be structured for optimal efficiency. For instance, many of the words that humans use when speaking do not convey actual lexical content, but are ‘function’ words such as articles, prepositions, auxiliaries and quantifiers. These grammatical elements are used to organise and refine the meaning of sentences’ content (Corballis, 2009). A major function of language use is in human beings’ ability to convey specific information between each other according to certain kinds of situations or needs. Ferguson explains that each unique context requires particular related vocabulary and expressions (Armstrong & Ferguson, 2010). Thus the function of grammar in forming and differentiating among different types of texts for different situations should never be ignored (Khan, 2011).
According to the literature reviewed for this study, one of the crucial areas in teaching and learning languages is that of the need to focus on the needs of the learners. This has led to the study and development of using language for specific needs or purposes, called ‘LSP’. Basturkmen (2002) defined LSP as a way of enabling language learners to survive in particular target environments where the learners are unfamiliar with the context-specific language use and its conventions. The demand for LSP programs and courses in many universities has increased because of globalisation. The existence of local economic needs to trade make understanding another language and culture necessary to effective competition (Uber, Grosse, & Voght, 2012). Scholars have been working in the field of language for specific purposes for over 20 years (Bowles, 2012), especially in teaching and learning English as a foreign language.

The dominance of English as the universal language is a real phenomenon of our time (Crystal, 2003). One reason for this is, of course, the political power of the United States of America, and of Great Britain before it. As an acknowledged expert on globalised English, Crystal (2003) claims that one in four people worldwide can communicate in English. The dominance of English has flowed over into the most crucial areas of modern life. English is now the formal language of technology, science, and tourism. English is also the language of international specialised forums, formal databases, airline companies, and most Internet content. The dominance of the English language has increased the number of English learners around the world to almost one billion, many of whom need to use English in fairly specialised professional or technical applications; hence the development of English for Special Purposes (ESP). The English language is also a mandatory course in most schools and universities of the world.
Researchers and educators have devoted much attention to the important function of language in efforts to improve the education process (Engel, 2009; Karbach, Kray, & Hommel, 2011) and produce a productive curriculum for the understanding of the areas of technology and particularly science (Fang, 2005; O’Toole, 2003; O’Toole & Laugesen, 2011). Moreover, it is increasingly recognised that the field of languages is not just about learning a foreign language with its particular structure, but also about focusing on the understanding of how one’s own language is structured and how it functions together in different areas. These researchers emphasise that it is necessary for one to learn their own language with as much effort as if they were learning a foreign language. Such detailed attention to the study of the grammatical structure of one’s native language is crucial to the ability to read, write and understand textual content comprehensively. Literacy goes far beyond merely encoding and decoding speech. The ability to know how to read and write in an appropriate way to enable effective response is crucial. Possessing reading and writing ability ultimately enables students to clearly voice their ideas in a clear vocal way about what they have learned in subject areas such as science (Rosenthal, 1996).

The focus of this thesis is on the Arabic language used in Saudi secondary school Physics textbooks. Textbooks are central to the learning of this key area of science because they are authorised as the basis of class work and are the official sources for teachers and students in Saudi schools (Al-Shamrani, 2012). This makes reading a very important part of learning in such classrooms.

3.2.1 Reading, writing, speaking and listening in science learning

One of the main focuses of teaching and learning in the education system is ‘how’ the teachers deliver the information and how it is received by the students. The
communication tools inside the classroom, for instance the textbook, ICT and the whiteboard, seem to be basic materials. Yet oral communication, the style of language being used, or a teacher’s body language, have a definite impact on the teacher and learner relationship. All these elements are interdependent on each other.

Such a context raises certain questions:

1- Does the teacher have ability in delivering such knowledge?

2- Is learning material like a textbook clear enough to read, so that it leads students to understand its specific content, and do the students’ achievements match with the expected learning outcomes?

To lay a deep foundation of textbook resource content within students necessitates emphasis on reading. Norris and Phillips (2003) assert this particular need of reading comprehensively in science, stating that it is the key to accessing scientific knowledge. Consequently, when a reader is able to overcome basic reading difficulties it will be easier for them to understand and learn from any type of scientific reading text. Burton (2014) points out that diversity of literacy levels among students reflect a decrease in correspondence between their actual reading ability and the level of their education.

The objectives of literacy in science are identified as reading, writing and oral communication by Carrier (2005), who points out that these objectives are based on reading, writing, listening, and note taking. She maintains that all of these language functions are part of science learning. Language is an intricate system resting on necessary cognitions and skills (Al-Hajaya, 2012). The language of science in particular,
is used to construe values and scientific knowledge and has a different pattern of linguistic features and social functions from everyday language (Fang, 2005). Students need to have specific skills which enable them to understand scientific texts (Van Lacum, Ossevoort, Buikema, & Goedhart, 2012). Thus, focusing on learning the language of science is essential to being able to comprehend science texts.

There is no doubt that the field of science has its own specialised language, at least within English. Both science and mathematics make use of formally stated laws and precise definitions in contrast to other subjects, such as humanities and social science, which tend to have broader and more flexible concept definitions (Lackovic, 2010). The scientific laws and definitions contain special symbols, formulas and technical terms which are essential to full comprehension of their content (Mikk & Kukemelk, 2010). Moreover, there are some terms in science lessons which have one type of meaning inside the science classroom but another meaning outside of the classroom in everyday life (e.g. mass), and certain scientific words which occasionally have colloquial meanings (e.g. matter) (Matson & Cline, 2012; Williams, 2011). Hanrahan (2009) asserts that to become literate in science requires development of student reading and writing skills. Many parts of the curriculum have special language functions and features which teachers and students encounter and must be adept in using. The mandated instructional texts may not correspond to the ability of students to understand them (Ghazi, Ali, Khan, Hussain, & Fatima, 2010).

The success of students in learning science relies on their ability to use effectively all of the literacy skills of listening, speaking, reading and writing. Literature suggests that when learning science in English, effective listening challenges students to analyse
speech and to respond suitably (Fang, Lamme, & Pringle, 2010). This requires students to be familiar with language structure in order to understand the intention of the text. Science text in English is highly structured, with conventions whereby each paragraph contains a main idea with supportive details (Hasmam & Rahimi, 2010; Montelongo & Herter, 2010). Such specialised text, whether constructed in Arabic or translated from English, forms one of a number of components within Arabic textbooks mandated for use in Saudi schools; also included are other components such as graphs and pictures. Textbooks play a critical role in the learning process due to the different activities they offer, thereby making lesson content the most important component of the textbook (Brown, 2009).

Science students are also required to work in groups and participate in discussions, requiring them to establish a language relationship with other speakers. Speaking together allows students to reflect on and compare their understanding of what they have heard in the classroom. Furthermore, their spoken responses assist teachers in evaluating student comprehension levels, which in turn allows the teacher to refine ways of helping students to prepare for reading and writing tasks related to their subject.

Reading is considered by most authorities to be the most important skill for improving student understanding of science, in both Arabic and English (Al-Sufi, 2009; Reeves, 2005). Students have to follow instructions from manuals and gather information and data from reference books, scientific journals and websites, all of which requires them to recognise the functional elements and purpose of the text. Scientific reading includes descriptive diagrams, tables and graphs, used to symbolise and describe scientific facts and concepts. Furthermore, in science, students are expected to use a variety of reading
techniques, such as taking notes, scanning and skimming, which require a lot of practice. Writing skills are as important as reading skills. Successful Science students need to be able to show an understanding of the different styles and types of writing techniques. They must also be able to use appropriate scientific and technical language, and to use diagrams and tables to convey meaning (Lackovic, 2010).

In comparing primary and High school science styles of text, both Bryce (2011) and Fang (2008) point to a gap in reading instruction between primary school with science narrative storybook reading, and intermediate school with scientific inferential and explicatory text analysis. The explicatory texts seem far more difficult for students to understand. When comparing the two different kinds of science texts, these researchers found that intermediate science texts have more specialised technical terms and a higher density of crystallised information, such as nominalisations, in order to condense the high level of information and concepts being presented in a single paragraph. Such condensation, however, causes the text to become less accessible, appearing dry and boring to intermediate science students. This characteristic of written science text stands in increasingly marked contrast to the much livelier visual and narrative presentation of science concepts in multimedia genres.

Herman, Perkins, Hansen, Gomez, and Gomez (2010) presented some results of the National Assessment of Educational Progress Reading tests in 2003 which required student constructive understanding of the meaning of particular assigned science texts. The results indicated that 70% of American students in Grade 8 were struggling to read their English language texts, and that these results were keeping them below the proficient level.
Considering the role of school textbooks in learning science, it appears clear that reading comprehension is central to understanding science texts effectively and this may be true regardless of the language of instruction. Patel (2010) showed that decoding is necessary to comprehending text. Johnson and Zabrucky (2011) however, find that many Middle and High school students are still struggling to decode science texts. One of the reasons for this is the introduction of new concepts and the need for more clarification of the content. New concepts and words in scientific texts are the most critical and basic points in learning science. In order for students to be able to overcome this huge threshold of limited past knowledge with the new knowledge demands of science lessons, students need to have a comprehensive foundation of scientific reading skills (Kroeger, Burton, & Preston, 2009). Students need to identify the relevant important information in a given passage (Cook and Mayer, 1988). This view is echoed by Al-Sufi (2009), who asserts that to be a good reader one should be able to extract the main idea in a certain passage.

3.3 Arabic language

The Arabic language is used in both instructional materials and classroom delivery throughout Saudi Arabia. An overview of its relevant characteristics is necessary here, before delving more deeply into the interaction between Saudi learners and their science textbooks. Arabic grammar in itself poses many language-specific complexities, but this section focuses only on those aspects of grammar that are relevant to the present study.

Arabic is a Semitic language (Azzam, 1989), and as such it is more closely related to Aramaic and Hebrew than to English and other Indo-European languages. Saudi speakers of Arabic regard the language itself as inseparable from the Islamic religion, because this religion originated in the Arabic language (Al-Sufi, 2009; Za’Rour & Nashif, 1977;
Zughoul & Taminian, 1984). Throughout the world, Arabic is recognised as the language of Islam (Versteegh, 2014). It is the language of the Holy Quran, the holy book for Muslims. More than 330 million people speak Arabic as a mother tongue in different dialects throughout the Arab world, while more than 1.4 billion Muslims use Classical Arabic when they perform their prayers five times every day, and when they study the Holy Quran and other religious teachings (World Atlas, 2018). Apart from the Classical or Quranic Arabic, the Arabic language of today exists in a wide variety of spoken forms, some of which are almost not mutually comprehensible without using the Modern Standard Arabic (MSA) of the news media and international communication.

### 3.3.1 Forms of the Arabic language

Arabic is often described as language exhibiting ‘diglossia’, because the spoken forms are very different from the written form (Diab, 2009). It would perhaps be better described as ‘heteroglossic’, as it has two written forms and many spoken or vernacular forms. The first written form, upon which the language of the Quran is based, is called Classical Arabic. This Classical Arabic has not been changed for more than 15 centuries (CIA, 2008), because of the cultural importance of preserving the religious texts in their original form. The second, mainly written form, called Modern Standard Arabic or al-fuṣḥā, is basically extended from Classical Arabic. This form is the language used in books, newspapers and some popular media and formal and religious speeches. Classical Arabic is the religious language, and is normally used for reciting Quran prayers and other Islamic duties; while Modern Standard Arabic (MSA) is a modern development from Classical Arabic with continuous borrowings from different languages to meet the changing needs for those who speak Arabic. It is used in education, media and general aspects of life (Diab, 2009). Classical Arabic and Modern Standard Arabic differ in that
MSA omits orthographic symbols that represent short vowels, which help the reader to read a word in Classical Arabic correctly (Farghaly, 2005).

Written Arabic uses an alphabet of 28 letters. It is written from right to left, with relatively little punctuation and no capital letters. The shapes of letters in Arabic change according to their location in the word (Farghaly, 2005). Each letter can appear in up to four different shapes, depending on whether it occurs at the beginning, in the middle, at the end of a word, or alone. Written Arabic does not have short vowels, capitalisation, or silent letters and it does not combine two letters in order to yield a new sound (digraph) as many other languages do (Farghaly & Shaalan, 2009).

The third form of the Arabic language is that of the spoken or colloquial language, termed *al-ammiyya* (Al-Sulaiti & Atwell, 2006). The spoken form of the Arabic language has great dialectal diversity, with hundreds of dialects around the Arabic-speaking countries, which are located from the Arabian Gulf in the East to the Atlantic Ocean in the West. These dialects have been strongly influenced by the Arabic literary language (Seraye, 2004). The mutual intelligibility of these dialects decreases across geographical distance (Ghazali, Hamdi, & Barkat, 2002). People from Lebanon can have difficulty in understanding most of the dialects used in North Africa. Common, everyday colloquial forms vary from one city to another within Saudi Arabia, or from one country to another across the Arab world (Boujaoude & Dagher, 2009; Ibrahim, 2011; Ibrahim & Aharon-Peretz, 2005). These forms vary greatly between the Arabic written language and the Arabic spoken language to a much greater extent than is the case for languages such as English or French.
None of the phonological systems for spoken varieties of Arabic are identical with that of standard Arabic, which means that even Arab learners of Arabic will have to learn some new sounds and, in the process of doing so, many will fail to reach the target norm (Ibrahim, 1983, p. 511).

The morphological and syntactic forms vary at least as much across spoken varieties as the phonological systems do. This means there is always a mismatch between the orthographic symbols of the written language and the phonemic systems of each Arabic speaker’s spoken language; and between the written words and sentences that Arabic speakers see on the page, and the words and sentence structures they hear and produce in everyday speech. Attaining literacy in such circumstances is no easy matter, even before we consider the literacies required for mastery in specialised areas of knowledge.

3.3.2 Grammar in written Arabic

Sibawayhi (c. 760-796), one of the greatest classical scholars of the Arabic language, divided the Arabic lexicon into three parts of speech: nouns, verbs, and particles. The present study uses categories derived from this work to describe its results (following Lancioni & Bettini, 2011). This brief summary highlights the features most relevant to this research.

1- **Nouns:** In Arabic nouns are defined as a name or a word that refers to a person, a thing, or an idea and are subdivided into ‘derivatives’ and ‘primitives’. Derivatives consist of nouns derived from verbs, from other nouns, or from particles (with corresponding morphological complexity), while primitives consist of nouns that are not derived from anything. Nouns can be subcategorised by gender, number and case. Further
distinctions divide nouns into subclasses of participles, demonstratives, pronouns, interrogatives and relatives. This is similar to the categories of classical European grammatical description (Khoja, 2001). Arabic nouns fall into two morphological types: nouns that can take the definite article, and indefinite nouns formed via ‘nunation’ (Ryding, 2005). Nunation (تنوين tanwīn) is a small sign added to the end of the word and pronounced as -un in the nominative case, -in in the genitive, and -an in the accusative (Al-Shahrani, 2008).

2- **Verbs**: The Arabic language is rich in verbs (Danks, 2011, p. 15). Verb classification in Arabic is similar to that of English, although the tenses and aspects are language-specific (Khoja, 2001). The Arabic verb appears in three different tense forms: past, present and imperative (Elsadany & Hashish, 1989).

Both verbs and nouns in Arabic are derived from roots by applying templates to generate stems to which prefixes and suffixes can be added, as shown in the examples following Table 3.1. The roots commonly consist of three or four letters, with five letters being very rare (Darwish, 2002).

3- **Particles**: The particle class contains adverbs, prepositions, conjunctions, grammatical particles, and interjections; along with a few exceptions that are not relevant here (Khoja, 2001). Of the nine conjunctions, most are written as individual words, except for the inseparable conjunctions (clitics) و (waw) and ف (fā), which are usually attached directly to a noun or a verb. Prepositions appear before nouns in Arabic and there are 20 different forms (Nwesri, Tahaghoghi, & Scholer, 2005, p. 207). Figure 3.1 shows the classification of Arabic words.
Arabic language morphology is rich and complex (Ben Fraj, Zribi, Othmane, & Ben Ahmed, 2010) with its characteristic elements of inflection and derivation. The categories of noun and verb in Arabic language are also characterised as declinable and indeclinable. The declinable words can appear in three different cases depending on the word’s position in the sentence, as illustrated in Table 3.1. On the other hand, the indeclinable words are in a fixed case form in any place in the sentence (Cachia, 1973; Elsadany & Hashish, 1989). Verbs are inflected for number and for gender. “Hence, the number of verb forms
in any given tense, is larger than in most other languages” (Versteegh, 2014, p. 46). The category of particles in Arabic includes the many subgroups shown in Figure 3.1 (Gharaibeh & Gharaibeh, 2012).

Table 3.1: Cases for Nouns and Verbs

<table>
<thead>
<tr>
<th>Verbs</th>
<th>Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1: Nominative</td>
<td>Case 1: Nominative</td>
</tr>
<tr>
<td>Case 2: Accusative</td>
<td>Case 2: Accusative</td>
</tr>
<tr>
<td>Case 3: Jussive of the imperfect</td>
<td>Case 3: Noun in the genitive</td>
</tr>
</tbody>
</table>

The complex word structure of Arabic is based on a root-and-pattern system of morphology (Meftouh, Laskri, & Smaili, 2010) which is highly irregular, and varies considerably across dialects. A single root, based on three consonants, can generate a dozen or more forms with different meanings, through processes of inflection and derivation. For example, irregular plural forms (called jam taksīr or ‘broken plurals’) are very common, and they illustrate how the various word forms involve far more complex changes than simple prefixing or suffixing. From a single root such as the three consonants (ك ت ب k t b) ‘to write’, the singular nouns كتاب، kātib ‘scribe’, كتاب ‘book’, مكتوب، maktūb ‘letter’ (among many others) are formed, along with their plurals كتاب، kutub ‘books’, كتاب ‘books’, مكتبة، makātib ‘letters’ (Hammond, 1988; Holes, 2004; Neme & Laporte, 2013)
Furthermore, some Arabic words may have the same written form but different meanings, corresponding to different pronunciations, which are indicated by the use of diacritics. For instance, the written word ﻓِﻠْم**ْ** can occur in differing contexts with the meanings ‘science’ ﻋِﻠْمْ (shown here with diacritics indicating the pronunciation ‘ilum), ‘flag’ (pron. ‘alam), and ‘he knew’ ﻋَﻠِمَ (pron. ‘alima), among other variations (Elshishtawy & Elghannam, 2012). The letter shapes and the vowels in the word are regarded as essential features of Arabic language orthography (Oweini & Hazoury, 2010). Not only do these variations of homographs represent distinctly different meanings, but they also represent differing grammatical forms, each with its own functions within the structure of the sentence (Abu-Rabia, 1997). This may sound very complex, yet these same diacritics are used in the Quran and from early stages of primary schooling (Nedwick et al., 2011). Omission of the diacritics may be a hindrance to comprehension for inexperienced readers (Al-Subaihin & Al-Khalifa, 2011).

A word in Arabic is derived from two or three consonants comprising the root morpheme, and as shown above, the addition of affixes and vowels to these roots produces variation in both meaning and part of speech (Abu-Hamour, 2013). Affixes can cause difficulty for readers in identifying word and suffix roots (Hmeidi, Al-Shalabi, Al-Taani, Najadat, & Al-Hazaimeh, 2010), as prefixes and suffixes are similar to some letter sequences in the root of the word (Al-Shawakfa, Al-Badameh, Shatnawi, Al-Rababah, & Bani-Ismail, 2010). The categories of prefix are conjunction, preposition and article (AbdelRahman, Elarnaoty, Magdy, & Fahmy, 2010). To give an example of such affixes, the word ﻮَبَﺤْﺴِﻨَﺎَﺗُﮭُﻢَ means ‘by their virtues’. If this word is divided into parts, the first element is the prefix w[a] ‘and’, a clitic conjunction; the second element is b[i] ‘by’, a preposition; h[f]a/snāt is the stem (‘virtues’) and h[f]u/m ‘their’ is a possessive pronoun.
An Arabic word can appear in different grammatical forms with substantially the same meaning by means of inflections such as gender, number, place or tense. Very few of the inflection patterns are regular, with simple prefixed or suffixed roots. Most are irregular forms, involving infixation and other complex affixation processes. The examples given earlier of كتاب kitāb ‘book’, كاتب kātib ‘scribe’ and their plurals كتب kutub ‘books’, كتاب kuttāb ‘scribes’, demonstrated inflection with the irregular (‘broken’) plural. In addition to grammatical inflection, another affixation process called ‘derivation’ creates a new word in the same semantic area but with different meaning. For example, the same root علم, mentioned above, has verb derivations علم ullama ‘notify/inform’, and إستئناف isti’ulām ‘inquire’ (Brahmi, Ech-Cherif, & Benyettou, 2012). A further challenge for readers encountering new vocabulary in Arabic is that, to look up an unfamiliar word in an Arabic dictionary, one has first to isolate the individual word within the text token, and then determine the underlying lemma (dictionary headword or citation form) and root forms, to know where to look. All Arabic words are listed under the relevant root, and then by the individual citation form (somewhat like English dictionaries showing inflected forms running and runs under the headword run, but on a much larger scale).

Understanding sentence structure is also crucial to reading comprehension. There are two types of sentences in Classical Arabic. The first is the nominal sentence, where the sentence begins with a noun or pronoun; the order is Subject-Verb-Object (SVO). The nominal sentence consists of two main parts, the first being the subject (al-mubtada’), which can be a noun or pronoun, signifying what the sentence is about. The second
element is a predicate \textit{(al-xabar)}: which tells us something about the subject. The predicate can be an adjective, verb or noun (Farghaly & Shaalan, 2009); and when it is a transitive verb, it may be followed by an object. An example of this type of sentence is the well-known \textit{takbir} or declaration of faith, ﷲاﻛﺒﺮ \textit{allāhu al-akbar} (‘God is [the] greatest’), where the subject noun \textit{allāh} ‘God’ is followed by the predicate noun \textit{al-akbar} ‘the great[est one]’.

The other sentence type is the verbal sentence, where the verb is in the beginning of the sentence; this type has the pattern Verb-Subject-Object (VSO). A typical sentence of this type is \textit{اﻟﻜُﺘﺐ اﻟﻄﺎﻟِﺐُ ﻗَﺮَاءَ} ‘the students read the books’ (literally, ‘read-Past the-students-Nominative the-books-Accusative’). This is recognised as a major syntactic difference from English, which allows only SVO. However, most of the spoken varieties of Arabic start only with the subject followed by the verb and the object (SVO). Unfamiliarity with the sentence structure of the written language could pose a further barrier to comprehension for learners.

Most Saudis, like other Muslims throughout the world, gain fairly extensive experience with the written form of Classical Arabic through frequent and lifelong religious activities. Muslims believe that the \textit{Quran} holds the literal words that the Prophet heard; the words he heard were in Classical Arabic and so it has become the language of Islam. Most of its international use has been for religious purposes, and even those Muslims who do not speak Arabic can read aloud from Classical Arabic text because it shows the vowel diacritics. But in Modern Standard Arabic, the vowel diacritics are not written. Hence it is hard for readers who are more accustomed to seeing religious text with diacritics, to read texts that do not contain vowels or dedicated letters that represent them (Farghaly & Shaalan, 2009).
3.3.3 Arabic language in schools

The role of Arabic as the language of instruction in Saudi schools highlights the importance of having reading skills in Arabic language. In schools, understanding the Arabic language is deemed fundamental for students to succeed in the many different educational pursuits. Its status as the official language of education also originates from the Holy book Quran. As the Arabic language is the only official language spoken in Saudi Arabia, it is considered one of the most critical tools for school students to achieve their goals. It helps the learners to communicate, understand and interact with their environment. Moreover, Arabic is the basis of all educational studies. All educational activities throughout all schools are performed through the four skills of listening, speaking, reading or writing in the Arabic language (Saadi, 2012).

As indicated in the previous section, reading in the Arabic language depends on the alphabetical technique (Elashhab, 2008) for the basic decoding of sounds and words. Beyond the basic phonic level, one of the major goals for teaching reading in the Arabic language in the early stages of the Saudi education system is to begin to develop students’ skills to understand, analyse, and evaluate a text (Saadi, 2012). Understanding the text is a specified target for students. Readers are expected to understand the written message of the writer at different levels: lexical, syntactic, semantic, and pragmatic (Aarnoutse & van Leeuwe, 1998, p. 144). Teaching the grammar of the written Arabic language is therefore, a high priority in Arabic classes due to the complexity of the grammar (Gebril & Taha-Thomure, 2014), and its differences from the spoken Arabic of the learners. In contrast, limited attention is devoted to improving students’ skills in phonology and morphology (Al-Ghanem & Kearns, 2015).
The scope of Arabic language instruction is restricted to teaching from the textbook provided by the Ministry of Education, with teachers being expected to finish it in order to meet the goal of any specific course (Taha-Thomure, 2008). This system of focusing on teaching from the textbook is ‘teacher-centred’ and as Taha-Thomure (2008) highlights, is therefore likely to be deficient in assessment, technology and instruction methodology. Buflaqah (2017) however suggests some key points to develop the teaching of the Arabic language, by designing a curriculum based on accurate experiences, research and experimentation. In regard to grammar, he suggests that the teaching of grammar must focus on the basic principles of spoken grammar in order that students would not be burdened with extraneous grammar details which would only cause distraction from their key learning.

3.4 Readability and comprehension

Readability is a relationship between two different variables: the reading materials and the reader. Examining the development of reading skills in learners needs to be balanced by a corresponding awareness of the suitability of the reading materials. As mentioned above, the issue of poor reading comprehension for English-speaking learners in relation to school science textbooks has been a research focus for some time, and is relatively well researched. The problems are not merely related to different levels of ability among students in understanding the text, but it is also about the type of text itself being used.

If viewed superficially, reading in general might seem like a simple process and, once the basic mechanics of reading are mastered, it may seem that any texts should be accessible (Norris & Phillips, 2003). However, reading science in English has been found to involve many cognitive activities and, as such, is a complex process (Phillips & Norris, 2009).
Koch and Eckstein (1995) state that to be a good reader in science requires reader ability to comprehend many different layers of detail in the text. Similar readability issues have been observed in mathematics texts. Al-Harbi (1994) comments that the apparent ability to read mathematical content correctly does not mean that students understand what they are reading. Reading comprehension skills, therefore, seem to be essential to the science courses themselves.

3.4.1 Measuring readability: The formula approach

Research on how to measure readability began in the 19th century, when Sherman (1893) conducted statistical analysis by examining sentence length to predict the reading levels of learners. He found that the length of sentences in academic texts became shorter over time. He concluded that writers were consistent in their idea of ‘average’ sentence lengths within their time context, thus allowing for accurate prediction of sample text usage in terms of validity of results in measuring readability levels. Klare (1963, p. 1) commented that one of the uses of assessment readability is “to indicate ease of understanding or comprehension due to the style of writing”.

More recently, Pang (2006) defines the readability assessment as a technique to appraise the level of reading difficulty in a piece of written text. The methods of measuring readability can be either through human involvement, such as comprehension tests or judgment by experts; or they can involve analysis of linguistic features, or the use of computational approaches, such as applying a readability formula (Pang, 2006; Saddiki, Bouzoubaa, & Cavalli-Sforza, 2015). Much of the existing readability research has been carried out in the English language.
An early attempt of employing the readability formula was by Lively and Pressey (1923) who were concerned about the load of technical words used in a practical science textbook for a junior high school which caused teachers to consume their class time in having to explain different terminologies (DuBay, 2004). The authors then focused on finding an effective methodology to reduce the ‘vocabulary burden’ (based on word frequency) commonly associated with text readability (Zhao & Kan, 2010). Since then, about 200 readability formulas have been produced (DuBay, 2004). The most popular formulas used from the 1940s to the 1960s were based on the elements of word familiarity and sentence length (Dale & Chall, 1948; Flesch, 1948; Fry, 1968; Gunning, 1952; McLaughlin, 1969). Other formulas were based on the feature of word frequency alone (Chall & Dale, 1995a; Klare, 1968). Most of these were for English text, but Bjornsson (1968) produced Laesbarhedsindex (‘Readability-index’, or LIX) for the Swedish language; his formula was based on the number of words and sentences in the text and the number of difficult words in the text.

Several innovations came as the research continued in the 1960s. Senter and Smith (1967) created a formula for the first Automated Readability Index (ARI), which was designed to assess the reading level that readers would need to comprehend a given text. McLaughlin (1969, p. 640), who produced the simple measure of gobbledygook (SMOG) formula, defined readability as, “the relationship between two variables, which in this case are a measure of the difficulty experienced by people reading a given text, and a measure of the linguistic characteristics of that text”. This brought new attention to the role of the reader in engaging with the text, in addition to the characteristics of the text itself. Romey (1968) created a formula to measure the degree of student involvement in a science textbook. His formula has been widely used in the Arabic readability research
literature, whether in assessing textbooks in science or other subjects, as is further detailed in Section 3.5.

3.4.2 Measuring readability with cloze testing

Another approach to assessing the ability of readers to access and engage with a given text passage is the cloze testing method, first introduced by Taylor (1953). Deleting words from a passage and then asking readers to replace them will produce a cloze test. In addition to its usefulness in testing reading comprehension, the overall cloze score is useful in investigating the readability level of a passage, and moreover, classifying the words deleted from the passage can help to determine more specifically where the readers’ difficulties lie. Bormuth (1965) regards the comparing of difficulties within different passages as the object of readability research. Individual learners’ language abilities and proficiency can also be examined by using a cloze procedure (Bachman, 1985). The advantages of the cloze test are that it provides a direct connection between the reader and the passage, unlike readability formulas that rest on comparison between texts (Gilliland, 1972; Stevens, Stevens, & Stevens, 1992). This type of test is also of practical value in teaching reading (Brown, 1980; Gilliland, 1972). The cloze procedure has long been used within education due to the demonstrated effectiveness and reliability of its results.

The cloze test usually involves the deletion of about 50 words from a passage (Oller & Jonz, 1994; Riley, 1978), although others have argued that it is sufficient to only delete 30 items (Bachman, 1985). Every fifth word should be deleted consistently (Alderson, 1979) with resulting blank spaces having the same length. There should also never be any punctuation or apostrophe in the word replaced (Robinson, 1981).
Cloze tests involve the deletion of a random word in the second sentence of a passage, then the deletion of every fifth (or seventh, ninth, eleventh or thirteenth) word thereafter until the desired number of words have been deleted (Gunning, 2002, pp. 390-393; Hughes, 1989, pp. 62-71; Lapp, Flood, & Farnan, 1989, pp. 352-354). A particular group of readers then tries to replace the deleted words. The group average of correct responses is interpreted as an estimate of readability access that the specific group would have to the meaning of the particular text.

The words which readers propose to fill the gaps left by the deletions that form a cloze test can be scored exactly (where only exact replacement of the deleted word will be coded as correct) or conceptually (where various synonyms or otherwise meaningful alternatives might be acceptable). The various uses to which cloze test results can be put, encourage adoption of either exact scoring or one of the conceptual alternatives. The number of deleted words ‘correctly’ replaced can be compared with one of a variety of criteria scores. The material from which the text sample was taken is considered to be too difficult for the target group (‘frustration’ level) if they score 37% or below; considered suitable for use with help (‘instructional’ level) if the group scores around 47%; or it may be easy enough for members of the target group to read it alone (‘independent’ level) if the average score is above 57% (Robinson, 1981).

A major attraction of cloze tests is that they allow researchers to challenge the text directly against a group of readers (Oller & Jonz, 1994; Spolsky, 2000; Stansfield, 2008). There is some long-standing controversy surrounding sampling errors in test generation and choice of scoring regime. Either of these matters could compromise the results of the present investigation. However, each of these issues has been the subject of recent
research and both proved to be less serious than might have been feared (O’Toole & King, 2010; O’Toole & King, 2011). Cloze tests have been used as overall measures of language proficiency, overall measures of text readability, validation of the results of application of readability formulas, and to assist in the identification of specific language difficulties.

Cloze tests have been used in educational studies and English language testing with such studies conducted in Iran (Ahmadian & Jalilian, 2012; Esfandiari & Ekradi, 2014); in Japanese and Russian ‘English as a second language’ learning (Kumazawa & Gakuin, 2016; Trace, 2016); in English reading comprehension (Garman, 2010); in assessing English textbooks (Obiora, 2016); in learning science in a native versus a second language (Ayodele, 2013; O’Toole & Schefter, 2008); and, in the press (Al-Zahrani, 2009).

The cloze test method has been used in other ‘non-linguistic or non-educational’ applications such as assessing the comprehensibility of company policies (Fanguy, Kleen, & Soule, 2004), and banks, web sites (Moscato & Moscato, 2005). Furthermore, cloze tests are used in the fields of health literacy (Friedman & Hoffman-Goetz, 2006) and financial information (Loughran & McDonald, 2014).

Although most widely used in English, the cloze method can be used in languages other than English, for instance, Korean (Oller & Jonz, 1994); Spanish (Gilbert, 1984; Raymond, 1951); and Arabic (Abanami, 1982; Gilbert, 1984; Ktait, 2002). The cloze test technique is currently widely used in the field of Education to design suitable language materials in textbooks (Mat Daud, Hassan, & Abdulaziz, 2013). The next section takes a closer look at both readability measurement and cloze test research in the Arabic language, to lay a firm foundation for the present study’s investigation of the language of passage(s) from a Year 10 Physics textbook.
3.5 Measuring Arabic language readability

3.5.1 Methodology for literature search

A systematic approach was applied with the aim of locating as much as possible of the available literature dealing specifically with Arabic language readability, as this was most directly relevant to the present study. The first stage of the literature review was restricted to research that has been published in the English language which was available on the University of Newcastle Library research databases such as ProQuest and EBSCO, and through Google Scholar. This yielded enough sources to form a basis from which to begin the research. A number of researchers from Malaysia have investigated Arabic as a second language (for example, Abdu-Ghani, Noh, & Yusoff, 2014), and others from the Middle East and North Africa (MENA) have researched different dialects of Arabic (Cavalli-Sforza, El Mezouar, & Saddiki, 2014). Earlier studies were conducted in American universities in the 1970s and 1980s, including those of Al-Heeti (1984); Sesi (1982); Toiemah (1978). Some recently published research used computerised analysis of text to measure readability levels (Al-Khalifa & Al-Ajlan, 2010; Al-Tamimi, Jaradat, Aljarrah, & Ghanem, 2013).

After this initial survey of the literature, a pilot study was conducted with 80 student participants, as reported in Chapter 6 of this thesis. Much of the literature published in English, such as articles by Al-Ajlan, Al-Khalifa & Al-Salman (2008), suggested that there had not been much previous research done in this area. Further delving into the thesis of Al-Heeti (1984) revealed that an earlier Iraqi research study appears to have been the first attempt to establish a readability formula for the Arabic language (Dawood,
1977). These two sources added to the impression that previous research had been quite limited.

However, after finding the research conducted by Dawood (1977), a report of another study conducted by Ktait (2002) was discovered in an article by Dagher and Boujaoude (2011). As a result, the scope of the literature search was broadened to include literature published in the Arabic language. This body of literature was far less discoverable than the English language scholarly publications indexed in the major research databases. Arabic language search engines yielded reports of other studies that had been conducted in Arab countries. Many of these were available only in the collections of different universities or by means of personal contact with the authors. The King Fahad Library in Riyadh contains all the studies conducted in all 28 Saudi Arabian universities under the Ministry of Education. There is also a Saudi Digital Library, established in recent years as the national online digital library in Saudi Arabia and the largest source of academic information in the Arab world, which provides a considerable number of Arabic databases.

An initial search of these databases yielded 45 papers relevant to this research. A more fine-grained search journal by journal revealed an additional 49 papers. Appendix B is a copy of the default version of the Excel spreadsheet that was generated based on publication date, encompassing all 94 of the studies that were finally included in this review. The construction of the spreadsheet and a systematic evaluation of these sources facilitated a more illuminating description of this internationally obscure body of research. Aside from the Arabic readability studies, there is also a body of literature which focuses on the evaluation of Arabic language textbooks using criteria such as the number
of photographs, the quality of the printing and use of colour, rather than the evaluation of the language in the textbook. Since this focus is outside the scope of my research, the reports of these studies were excluded from this review. Nonetheless, the relative inaccessibility of much of this literature to an English-speaking audience encourages a more detailed treatment of it here than would be strictly demanded by the research topic.

3.5.2 Overview of Arabic text readability studies

The earliest efforts to address issues of readability in Arabic were by teachers of religion who made an early attempt to simplify the religious text. They focused on specific Arabic words that were perceived as difficult, and sought to simplify the ideas by introducing them through more familiar words (Yonnies, 1976). The extensive Arabic literary heritage, especially during the late seventh century, paid much attention to books, the quality of writing, and the art of rhetoric (Yonnies, 1976).

Since its inception in 1975, contemporary research into the readability of Arabic language texts has continued at a rate that is still increasing. From the available sources, 94 studies focusing on measuring readability, computer applications or producing a formula were identified for the current research. The Kingdom of Saudi Arabia (KSA) has produced the greatest number of studies related to the topic of measuring school text readability, with 28 studies out of a total of 94 (See Table 3.2).
Table 3.2: Arabic readability studies

<table>
<thead>
<tr>
<th>Years</th>
<th>Nation (number of studies)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977-79</td>
<td>Iraq (2) / USA (1)</td>
<td>3</td>
</tr>
<tr>
<td>1980-89</td>
<td>KSA (2), Jordan (2), Iraq (2), Egypt (1), U.S.A (1), Not specified (1).</td>
<td>9</td>
</tr>
<tr>
<td>1991-99</td>
<td>Jordan (4), Palestine (1)</td>
<td>5</td>
</tr>
<tr>
<td>2001-10</td>
<td>Egypt (4), Bahrain (1), Jordan (8), Palestine (2), UAE (1), Iraq (1), Oman (1), Kuwait (2), Yemen (2), KSA (4), Malaysia (1), Sudan (1).</td>
<td>28</td>
</tr>
<tr>
<td>2011-18</td>
<td>KSA (22), Jordan (9), Iraq (2), Egypt (1), Palestine (4), Malaysia (6), Morocco (2), Kuwait (1), Iran (1), USA (1)</td>
<td>49</td>
</tr>
</tbody>
</table>

Research focusing on readability in language, especially that which focuses on automated and computerised readability measurements (Al-Ajlān et al., 2008; Forsyth, 2014) has been mainly published in languages such as English, Spanish, French and German, with fewer studies published in Arabic. The literature on readability in Arabic is widely scattered, much of it in unpublished theses and papers. Consequently, the following discussion examines these studies grouped under the headings of their specific features: readability formulas, computerised text applications, cloze testing, combined approaches, and investigations of linguistic style affecting readability. More detail can be found in Appendix B.

### 3.5.3 Developing readability formulas for Arabic text

Table 3.3 includes all of the identified studies that produced a formula to measure the readability of Arabic text. Some of these used a combined approach to measure text readability level, including student results from both cloze and comprehension tests, and computer programs as well as text features such as word frequency and sentence length. As can be seen in Table 3.3, the work on producing formulas for measuring Arabic
readability began relatively slowly in the 1970s and 1980s, after many formulas had been produced in the English literature reviewed above, and has flourished in more recent times.

Table 3.3: Arabic readability formula

<table>
<thead>
<tr>
<th>Authors of study</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dawood (1977)</td>
<td>$G = (0.0533W) - (0.2066S) + (5.5543P) - 1.0801$</td>
</tr>
<tr>
<td>Al-Basuni (2001)</td>
<td>$R_1 = -6.145S + 87.373$</td>
</tr>
<tr>
<td></td>
<td>$R_2 = -5.657S - 116.6532$</td>
</tr>
<tr>
<td>Al-Ajlan et al. (2008)</td>
<td>$S$ reliably indicates Arabic text difficulty</td>
</tr>
<tr>
<td></td>
<td>$R_1 = -4.42S + 2.03$</td>
</tr>
<tr>
<td></td>
<td>$R_2 = 1.96S + 8.73$</td>
</tr>
<tr>
<td></td>
<td>$R_3 = 0.15S + 25.5$</td>
</tr>
<tr>
<td></td>
<td>$R_4 = 0.15S + 10.84$</td>
</tr>
<tr>
<td>Al-Tamimi et al. (2013)</td>
<td>$R = 3.28N + 1.43W + 1.24S$</td>
</tr>
<tr>
<td>Mat Daud et al. (2013)</td>
<td>The total reversed ranking of each word in a sentence minus number of words per sentence gives the level of readability of written text</td>
</tr>
</tbody>
</table>

**Key:**
*Symbols have been harmonised for ease of comparison*

- $G$ is grade level
- $W$ is average word length
- $P$ is average paragraph length
- $R$ is ‘readability’
- $S$ is average sentence length
- $N$ is total number of characters

The most influential pioneer of this field was Dawood (1977), who produced the first readability formula for Arabic. Al-Heeti (1984) used Dawood’s linguistic features to further develop readability formulas using Judgement ANalysis (JAN), which is a tool to predict the readability of texts, based on the judgement of expert readers (see Chapter 5). These two formulas were constructed using different techniques and language analyses at the elementary school level in Iraq, thereby achieving some degree of result triangulation.
Student results from both cloze and comprehension tests were used to measure readability in a number of separate studies. Al-Basuni (2001) developed two readability formulas, one from write-in cloze and the other from multiple-choice results. Rashed (2009) produced four formulas, with each formula based on different language features: average word length, the percentage of noun sentences (SVO), and the percentage of verbal sentences (VSO).

Using Al-Heeti’s (1984) formula, together with the English-based Automated Readability Index for English language (ARI) and the Laesbarhed (‘Readability’) index for Swedish language (LIX), Al-Khalifa, et al. (2010) developed formulas to measure the level of readability for a group of passages from Saudi primary and intermediate textbooks. Their results supported earlier suggestions that average sentence length is a reliable indication of textual difficulty in Arabic, but the researchers concluded that the average word length was an unreliable measure, contrary to Al-Heeti’s conclusion (see Chapter 5). The more recent work of Al-Tamimi, Jaradat, Aljarrah, and Ghanem (2013) is also discussed in more detail in Chapter 5. Their research produced a readability formula based on computerisation of 1196 texts from different Jordanian textbooks.

A study conducted by Mat Daud, Hassan, and Abdulaziz (2013) suggested that previous formulas neglected the fact that some words were more frequently used than others, leading to overexposure of easier words with resulting under-representation of low frequency words and the consequent likelihood that the Al-Heeti (1984) and Dawood (1977) formulas underestimated reading difficulty for learners of Arabic as a second language. Mat Daud’s co-authors Hassan and Abdulaziz derived a corpus of Arabic text from books, newspapers, magazines, dissertations, referred journals, school text books,
the Internet, newswire and government reports, to form the King Abdul Aziz City for Science and Technology Arabic Corpus (KACSTAC). This enabled them to base their formula on a larger corpus of MSA than any previous attempt had achieved.

The corpus was analysed to calculate word frequency, and the researchers used this to calculate the average proportion of less-frequent words in different texts. Their assumption was that more frequently used words were easier to read, and that texts with many less-frequent words were harder to read. Therefore, the easier text was the text with the lowest score. Reversing the ranking allows derivation of a corpus-based readability formula, where ‘reversed ranking’ is an indication of words of higher frequency within the corpus: The total reversed ranking of each word in a sentence minus the number of words per sentence gives the level of readability of written text, according to this most recent formula.

### 3.5.4 Computerised applications of readability formulas for Arabic

Table 3.4 summarises the identified studies that used computerised texts and/or corpora to produce a readability formula as mentioned in the previous section, or to establish whether a program and test of this program are valid. Due to the limited studies found which focused on programming to develop the readability formula, the following section describes and illuminates the main characteristics of each study.

Houston et al. (1987) used paired comparison (JAN-PC) and compared it with the technique of Judgement Analysis (JAN) of particular texts to evaluate the readability of these texts. They concluded that paired comparison gave more consistent results than the ranking procedure. More details can be found in Chapter 5.
Studies conducted by Al-Ajlan et al. (2008) and Al-Khalifa and Al-Ajlan (2010) are described in the preceding section and in Chapter 5. Both of these studies were important in terms of improving the Al-Heeti formula and as a basis for work conducted by Forsyth (2014) which is described below.

Table 3.4: Computerised readability formulas

<table>
<thead>
<tr>
<th>Authors</th>
<th>Basis/ study context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston, Al-Heeti and Al-Harby (1987)</td>
<td>Used Al-Heeti formula and 5 linguistic variables and used JAN-PC (see Chapter 5).</td>
</tr>
<tr>
<td>Al-Ajlan et al. (2008)</td>
<td>Used texts to develop a computer program to produce the readability formula (see Chapter 5).</td>
</tr>
<tr>
<td>Al-Khalifa and Al-Ajlan (2010)</td>
<td>Used 150 texts from different levels of Saudi textbook</td>
</tr>
<tr>
<td>Mat Daud et al. (2013) and (Al-Tamimi et al., 2013)</td>
<td>Used texts to develop a computer program to produce the readability formula (see Chapter 5)</td>
</tr>
<tr>
<td>Cavalli-Sforza, El Mezouar &amp; Saddiki (2014)</td>
<td>Were able to develop a model that can successfully predict whether a text is appropriate for learners at the level of the first 5 chapters of Al-kitaab and less reliably determine if suitable for specific stages</td>
</tr>
<tr>
<td>Forsyth (2014)</td>
<td>Machine learning approach and TiMBL</td>
</tr>
<tr>
<td>Saddiki et al. (2015)</td>
<td>Used a small set of easily computed features to indicate the reading level of text</td>
</tr>
<tr>
<td>Rahman, Zaini, Husaini, &amp; Elias (2016)</td>
<td>Produced computer program to measure the readability of the texts.</td>
</tr>
</tbody>
</table>

Mahmoud (2012) compared the Al-Basuni (2001) and Al-Heeti (1984) formulas with the professional judgments of 125 teachers to estimate the readability level of the Arabic language textbooks for Years 3, 4 and 5 in Egyptian schools. The results of the formulas and teacher judgments both suggested that these textbooks were at an instructional level. All the previous formulas had been produced based on the Arabic language text book and
the application of those earlier formulas is very rare. The recent studies of Al-Tamimi et al. (2013) and Mat Daud et al. (2013) also used computer programs to produce readability formulas, as discussed in the preceding section and in Chapter 5.

Machine learning (ML) methods have been the focus of much research in the past decade and, among other applications, have been specifically applied to readability prediction. Forsyth used a Defence Language Institute (DLI) corpus of 179 documents of MSA and 74,776 tokens to develop a system using ML to “automatically predict” the readability of MSA (2014, p. 9). He ranked the documents based on the Inter-agency Language Round Table (ILR) which comprised eleven proficiency levels.

Forsyth found the DLI corpus to include five ILR levels: 1, 1+, 2, 2+ and 3, all of which represented easier levels within the scale. He divided the DLI corpus into training, development tests and evaluation. The first two covered 80% of the corpus (58,565 tokens) while the evaluation set contained the remaining 20% (16,211 tokens). The training and development sections were subdivided by another 80/20 split. Forsyth then examined discourse and lexical features from each document. These were word length, word list and novel lexical features. The Tilburg Memory Based Learning (TiMBL) machine learning approach was then applied to predict the ILR level of each document. A 10-fold cross validation for the two levels of classification task (3-level and 5-level) was used and the division of 80/20 was used for the 5-level classification task. Although he was working with a small corpus, Forsyth’s findings showed that the combination of lexical, traditional and discourse features were successful in predicting MSA readability, if at a slightly lower significance than was measured by Al-Khalifa and Al-Ajlan (2010) with F-scores of 0.719 and 0.519 respectively, as opposed to 0.778.
A predictive model for shaping an appropriate level of learning Arabic (MSA) as a second language at intermediate level was also sought by Cavalli-Sforza and co-workers (2014). These investigations focused on vocabulary content in texts, and the relationship between student knowledge and text vocabulary. These researchers used three sets of texts: 23 samples from the *Al-kitāb* textbook, which is commonly used with students for whom Arabic is a second language (Instructor text); and, a group of 10 samples for primary, middle and high schools (Syrian school texts); 10 samples from the Web (Internet texts). They divided the vocabulary of the samples into Known, Targeted, and Unknown. Known vocabulary was defined as words which the learner already knew from a previous stage, while Target vocabulary are the words intended to be learned in this specific stage. Unknown vocabularies are the words that students have not been exposed to or had as targets to be learned. The words were categorised into four levels: (1) ‘High’ competence words, (2) ‘Medium’ competence, (3) ‘Low’ competence, each of which has three types of words, and Category (4) ‘Other’ competence, comprising the words that were not given focus. A decision was made that if the words were categorised in the ‘High’ competency word range these words would be targeted. This analysis was performed by using the Morphological Analyses and Disambiguation for Arabic (MADA), which breaks the texts into sentences and then groups them according to lemma ID. The Buckwalter lemma ID is an indicator of the specific sense of the word if more than one sense is possible and these were also manually associated with each vocabulary item in the curriculum (Roth, Rambow, Habash, Diab, & Rudin, 2008).

Examination of the relationship between text vocabulary content and curriculum revealed that the number and proportion of the targeted words increased when the learner advanced to the next stage. Correlation between the language features of different texts revealed
that the following features are key indicators of the complexity of the texts in this corpus: average sentence length, average word complexity, and text length. However, the results also showed that the percentage of targeted words in Syrian textbooks and Internet texts was less than in the sample texts from the *Al-kitāb* textbook.

In an even more recent computerised assessment of text readability for Arabic as a foreign language used machine learning (ML) and natural language processing (NLP) to evaluate lexical, morphological and semantic features in calculating the readability of text, and arrived at a small set of easily computed features that can indicate the reading level of an Arabic text (Saddiki et al., 2015). These features included morpheme counts, type-and-token counts (ratio of the number of different words to the total number of words, where common words occur repeatedly), parts of speech, and various measures of sentence and document length.

### 3.5.5 Cloze test measurement of readability in Arabic

A number of studies over the past 70 years have used cloze testing as a tool for readability measurement in research aimed at ascertaining readability levels of specific textbooks. These studies set access criteria at whether readers are able to comprehend the text on their own (Independent); with assistance from the teacher (Instructional); or, whether comprehension is too difficult (Frustration), although they differ slightly in the scores at which they set each criterion (see Table 3.5).
Table 3.5: Cloze scores corresponding to Arabic access criteria

<table>
<thead>
<tr>
<th>Source</th>
<th>Criteria</th>
<th>Examples of Arabic users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harrison 1984</td>
<td><strong>Independent:</strong> Above 50%</td>
<td>Al-Bardi (2013), Al-Malky (2012), Al-Rugaib (2014) <strong>and very many others.</strong> This is plausibly the most commonly used set of cloze criteria used in research into readability in Arabic.</td>
</tr>
<tr>
<td></td>
<td><strong>Instructional:</strong> 40 to 50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Frustration:</strong> Below 40%</td>
<td></td>
</tr>
<tr>
<td>Bormuth, 1969, 1975)</td>
<td><strong>Independent:</strong> 90 to 100%</td>
<td>Al-Abidi (2012), and Da’na (1988)</td>
</tr>
<tr>
<td></td>
<td><strong>Instructional:</strong> 90 to 75%</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Frustration:</strong> Below 75%</td>
<td></td>
</tr>
<tr>
<td>Rye (1982)</td>
<td><strong>Independent:</strong> 90 to 100%</td>
<td>Abdu-Ghani et al. (2014) and Arifin, Halim, Sham &amp; Shukry (2013)</td>
</tr>
<tr>
<td></td>
<td><strong>Instructional:</strong> 75 to 89%</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Frustration:</strong> Below 74%</td>
<td></td>
</tr>
<tr>
<td>Betts (1954)</td>
<td><strong>Independent:</strong> 90 to 100</td>
<td>Abanami (1982)</td>
</tr>
<tr>
<td></td>
<td><strong>Instructional:</strong> 75 to 89</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Frustration:</strong> 74 to 50</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Beyond Frustration:</strong> 0 to 49</td>
<td></td>
</tr>
</tbody>
</table>

The most commonly used criteria scores in Arabic readability research are those devised by Harrison (1984), where scores of 50% and above indicate that the students read the passage independently; 40-50% means that students needed their teacher’s help to read the passage; and the frustration level occurs when the students score 40% or less. As these
scores are in widespread use (for example, Al-Bardi, 2013; Al-Malky, 2012; Al-Rugaib, 2014), they can plausibly be assumed when no criteria are specified.

Abdu-Ghani, Noh, and Yusoff (2014) recognised that a quantitative estimate of readability in Arabic would allow instructors of non-Arabic speakers to select more appropriate text for their classes. They used cloze tests completed by 390 students in Malaysia to measure the readability level of three passages from the BAT textbook *Arabic for Beginners*, by M.S. Adly, and language analysis of 15 Arabic reading texts to identify the potential of linguistic features with a high correlation with the results of the student cloze test. The findings suggested that all passages were at the frustration level (37% or below) according to the Rye (1982) measurement score for readability level. The researchers suggested that some linguistic features of Arabic had a negative impact on readability for non-Arabic speakers, including complex sentences, long verbal sentences, derivatives, content dense abstract words, affixes and word forms; and that these linguistic facts should be taken into account in the development of Arabic readability formulas.


Arabic cloze tests used the same three scoring methods as the English studies mentioned above: the exact method counted only exact replacement as correct, the conceptual
method accepted synonyms or other meaningful alternatives, and some studies employed multiple choice, which could be scored automatically and with high reliability (Table 3.6).

Table 3.6: Exact or conceptual scoring of cloze tests

<table>
<thead>
<tr>
<th>Total number of cloze studies</th>
<th>Using exact answers</th>
<th>Using conceptual answers</th>
<th>Using multiple choice cloze</th>
</tr>
</thead>
<tbody>
<tr>
<td>89 studies</td>
<td>74 from 89</td>
<td>25 from 89</td>
<td>27 from 89</td>
</tr>
<tr>
<td>10 studies did not provide any information for any of the categories.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Early research (Dawood, 1977) employed the cloze test with exact scoring. Research that followed suggested that the use of cloze tests in measuring the readability of the Arabic language in textbooks is reliable and scoring conceptually is also reliable (Toiemah, 1978), although Table 3.6 shows that the majority of the studies used exact scoring. Sesi (1982) constructed cloze tests of nine passages with every fifth word deleted for Arabic native speakers in Iraq, concluding that the average score variations that she found among passages and grades indicated the validity of using cloze tests in the Arabic language. Although most of the Arabic research only accepted exact word replacement (for example, Al-Auamleh, Al-Suwailmin, & Abu-Alshaikh, 2010; Al-Matrafi, 2010; Jawarneh, 2008), some researchers used conceptual scoring, accepting any words with the same meaning as the words deleted (for example, Al-Rashidi, 2005; Al-Zahrani, 2009).

These studies were designed to measure the level of readability in textbooks for particular subjects, such as Geography (Abanami, 1982), History (Al-Howaity, 2010), Islamic
Studies (Al-khaldi, 2013), Arabic language (Al-Rashidi, 2005) and Science (Al-Asadi, 2012; Al-Auamleh, Al-Suwailmin, & Abu-Alshaikh, 2010; Al-Bardi, 2013; Al-Matrafi, 2010; Bugahoos & Ismaeel, 2001; Ktait, 2002). The findings of these studies suggest that the readability levels of most of these textbooks were in the frustration range. Bugahoos and Ismaeel (2001) argued that one of the reasons for these negative results is that most MENA students have an inability to comprehend certain words and how these words affect context and student understanding.

In contrast, other studies suggested that textbook readability level were suitable and students in these studies reached the instructional level (such as, Al-Enizy, 2012; Al-Shelhob, Abdulhamid, & Al-Rwais, 2014; Ambosae’di & Al-Erimi, 2004).

A substantial number of studies used the multiple choice cloze approach. Bin-Isaa (2015) employed a cloze test for Year 7 which consisted of four passages with eight questions, attempted by 723 girls in Riyadh schools. This study indicated that the majority of students (80.22%) were able to reach the independent level, with 13.97% in the instructional level, and only 5.81% falling into the frustration level (on Harrison’s criteria).

A study conducted by Al-Rugaib (2014) examined the use by 254 Year 7 girls in a Riyadh school of their Arabic language textbook. The deleted word could contain a prefix or a suffix, which might be a preposition, pronoun or any of the clitic letters, as one word, except in the case where these affixes or suffixes were separated from the word which would be counted as two words. The results suggested that the readability of the text for these students was at the instructional level.
Studies of the readability of Arabic and Balaghah textbooks for non-Arabic speakers were conducted in Malaysia; the latter being a book of hadīth, comprising sermons, letters and sayings of the Shi’ite Imam ’Ali (Zamri, Arifin, Halim, and Bakar, 2013); Arifin et al., 2013). The results of both studies suggested that the text was disappointingly difficult for the students to read.

3.5.6 Combining Cloze and formula approaches

Researchers in Arabic readability have also assessed the level of readability by using cloze tests in conjunction with Romey’s (1968) readability formula. Most of these studies sought to assess readability for students by testing them with a cloze test, and also to assess student involvement by applying Romey’s formula (Abdullah & Enaiza, 1994; Al-Malky, 2012). Nazari and Khatibi (2017) tested Fry’s (1968) graph on the Arabic language textbook in Iran. They found the text level to be appropriate in terms of sentences but not suitable for the syllabus and concluded that Fry’s formula was not applicable for Arabic passages.

3.5.7 Linguistic features affecting Arabic readability

Fewer studies than anticipated were found focusing on identifying the language features that might create text difficulty, and only a small number of these used cloze tests. Of this small group of studies that identified language features causing reading difficulty, all were investigating the readability of school textbooks.

Jurdak and Sawaya (1980) identified the language features that could affect readability of a Year 7 Mathematics textbook and found that the mathematical concepts and unfamiliar symbols affected the readability of the Mathematics textbook more than the
features of Arabic language itself. Gilbert (1984) found that student performance on cloze items relying on lexical cohesion was better than on the grammatical items (See Chapter 7). Jadan (1989) investigated the Arabic textbook in Jordan for Year 5. Although this study revealed that the students were able to reach Independent level, it found that a number of language features made the passage difficult for these primary school students: adverbs, passive voice, and prepositional phrases.

Momani and Al-Momani (2011) chose a cloze test with every fifth word randomly deleted from a passage from a Year 4 Jordanian Arabic language textbook. Most student results (96.6%), fell into the frustration band, while only 2% of the students were at the instructional level. Just 1.4% of this student sample would have been able to read the text independently. They report that most students were misunderstanding verbs, nouns and articles.

Al-Adammat (2014) concluded from his study that the difficulty of the Arabic textbook used for Year 5 in Jordan is caused by long sentences, frequent use of terminology and a surfeit of ideas.

3.6 Gaps in the research

The international literature on English for Specific Purposes raises the question of whether similarly subject-specific forms of Arabic emerge in scientific contexts? If they do, what are the features of this style that may cause identifiable problems for learners? Learning science in one’s native language is not necessarily easy (Boujaoude & Dagher, 2009) and this is the moot issue on which this research will focus. Al-Subaihin and Al-Khalifa (2011) indicate that Arab communities might suffer from diglossia. As has been
previously suggested, the standardised form (MSA) is not anyone’s actual native language and there is wide regional and colloquial variation (Cavalli-Sforza et al., 2014), making MSA effectively a second language for most Arabic speakers (Abu-Leil, Share, & Ibrahim, 2014; Khamis-Dakwar & Khattab, 2014). A central issue underlying this situation is the difference between textual formal writing and the colloquial spoken dialects. Amin (2009) has noted that the multiplicity and diversity of linguistic aspects of grammar, vocabulary and phonology across the wider Arabic language region present substantial problems for teaching and learning.

Reading skills form a substantial key to the achievement of learning and education goals (Maamouri, 1998) but reading in Arabic is complicated in terms of lexical diversity and the great distance between Modern Standard Arabic (MSA) and everyday spoken language (Abadzi & Martelli, 2014), with beginning readers experiencing particular challenges with Arabic morphology (Abu-Rabia, 2002). It is therefore unsurprising that teachers see improvement of students’ reading skills as important in Arabic literature classes. However, the situation in science classes is similar to that prevailing in the West. Most science teachers see the transfer and explanation of scientific knowledge and guiding students’ practical work as their most important missions, and they do not necessarily see this as connected with reading skill or other language skills (Ambosae’di & Al-Erimi, 2004).

In the evaluation of textbook readability, expert judgment from teachers, and their ranking of particular passages have not been used as tools for comparison of different school texts. This is an omission, as they are the experts in the school subject. The lack of contribution
by the experts in identifying the level of text in term of readability in the literature required more investigation.

Moreover, cloze test results are most often used to determine the readability level of a text for a particular group of readers, and this involves counting the number of gaps correctly filled and comparing the average total with criterion scores. There is substantial work occurring in this area; however, most of the studies only identify the level of readability of such texts. The aim of the present research is to fill this gap by identifying the language features that cause students difficulties in reading their physics textbook.

There has been considerable change to the new Saudi science curriculum in terms of the English used, and the style of teaching. There is a need to examine the perceptions of teachers and students related to these changes and their effects on science learning.

These gaps in knowledge and research about the readability of Arabic school science textbooks, and whether readers’ difficulties can be linked to specific linguistic features in the text, confirmed the initial direction of this research. They guided the formulation of the research questions around assessing readability of the Physics textbook, investigating patterns of reader difficulty in relation to language features in the text, and considering broader questions related to learner backgrounds and matters of science curriculum policy and implementation. This thesis comprises a sequence of research papers and chapters which contribute to the literature related to assessing text readability, and aims to fill some of the current gaps in knowledge about the Arabic language in education.
3.7 Summary

This chapter reviewed research in the field of science education in relation to language, reading and assessment in terms of appropriate textbook readability for particular student groups. More literature on readability produced in Arab countries was found than had originally been expected, and this became a major focus of this review, since the Arabic language is the main medium of instruction for school physics in Saudi Arabia.

This literature provides a clear foundation for using both expert judgement and cloze testing methods to assess readability of school textbooks. However, there remains a looming question around the appropriateness of the specialised style of the written Arabic language used in general textbooks and in science textbooks particularly. Cloze tests, the readability formulas and judgment analyses are all important instruments in articulating Arabic language readability; however, there is a need to dig deeper into the causes of reading difficulties. To restate the Research Questions:

1. Do text samples drawn from textbooks for a range of Saudi Year 10 subjects differ in readability?
2. Do experts in Arabic language rate Year 10 Saudi science text as relatively hard for students to read?
3. Do some Saudi students have trouble in reading a mandatory science textbook?
4. Does a close linguistic analysis of Saudi students’ replacement of regular deletions from an authentic Physics text reveal a pattern of language difficulty?
5. Does any such pattern match existing data to the problems faced by English-speaking students with the language of their science books?
6. How do prior knowledge, language variety and parental education influence student performance when reading?
7. What are the teachers’ and learners’ perceptions of the latest Saudi science education reform with specific relation to Physics, particularly in terms of the style of written language in the textbook and of the new teaching strategies that are required?

The next chapter describes the methodological framework that was developed for this study’s purposes.
Chapter 4: Methodology

4.1 Introduction

The aim of conducting social science research is to comprehend human social behaviour and experience by describing and explaining the reality with specifically selected research methods (Morse, 2003; Neuman, 2006). This chapter focuses on the major investigation of this research which is the language use in the Physics textbook for Year 10 girls in Saudi Arabia. This study was conducted in two cities in Saudi Arabia: the port city of Jeddah and the southern inland provincial capital Abha. From respect for Saudi cultural values and the complete institutional separation of male and female education, the study was conducted in schools attended only by girls (Shaw, 1994; Troudi & Alwan, 2010).

This chapter provides an overview of the mixed research methodology employed in this study. Creswell (2012) suggests that mixed methods have the power to yield a deep understanding of research problems, and this investigation followed his explanatory sequential plan. The mixed method approach was selected as the most suitable for addressing the research questions (Johnson & Onwuegbuzie, 2004), which called for some flexibility in seeking answers of different kinds. Mixed method is, as Gilbert (2008, p. 126) pointed out, “self-evidently to be the use of two or more methods in a single research project”.

4.1.1 Research paradigms

Before detailing the procedures used, a consideration of the overall research paradigm chosen for this study will be helpful. The research paradigm helps the researcher to explain the reason for the choice of methods used in the research (Creswell, 2009). This
notion of paradigm originated with the American philosopher and physicist, Thomas Kuhn (Kuhn, 1962, p. 10). His definition pertained to what he called ‘normal science’, that is, the relatively stable and mature process of scientific research in between periods of scientific revolution. Later, he clarified the concept of ‘paradigm’ as a consensus among researchers whose education was based on a shared core of values, principles and assumptions and who agreed on ‘models’ of high quality research (Johnson, Onwuegbuzie, & Turner, 2007; Kuhn, 1977).

The word ‘paradigm’ has been widely used in the methodology of social science research with different meanings than those used in physical or natural science research (Morgan, 2007). While Kuhn originally intended the concept to apply in the natural sciences rather than the social sciences, social scientists themselves embraced with enthusiasm his challenge to articulate their underlying world views, assumptions, research programs, and research traditions. E. G. Guba (1990, p. 17) defined the paradigm as ‘a basic set of beliefs that guide action’, and identified four successive dominant paradigms that have guided scientific research: Positivism, Post-positivism, Interpretivism (sometimes called Constructivism) (E. Guba & Lincoln, 1994) and Pragmatic paradigms (Johnson & Onwuegbuzie, 2004; Morgan, 2007).

In any project, the choice of methodologies and methods of research is linked essentially to the way in which the researcher addresses central questions of ontology, epistemology and the adoption of relevant research models or paradigms (Mockler, 2011). Each paradigm comprises four elements: ontology, epistemology, methodology and methods (Scotland, 2012). The term ontology concerns the form and nature of reality (Guba & Lincoln, 1994). Epistemology concerns notions of ‘knowing’, ‘reality’ and ‘knowledge’;
that is, how humans conceptualise reality. Proceeding from these bases, methodology comprises the reasoning behind the selection of procedures employed to obtain knowledge, and methods are the techniques or research tools used to find answers to research questions and gather and analyse the data (Crotty, 1998). This chapter discusses the reasons why this study employed both quantitative methods such as surveys and tests, and qualitative methods such as interviews and open-ended questions, before proceeding to describe the research tools in more detail.

Positivism, one of the most influential paradigms, is based on knowledge that ‘consists of verified hypotheses that can be accepted as facts or laws’ (Guba & Lincoln, 1994, p. 113) which in turn rely for their verification on statistical data (Mack, 2010). The Interpretivist paradigm, in contrast, refers to an individual’s construction of meaning (Guba & Lincoln, 1994; Mack, 2010; Wiersma & Jurs, 2009) and allows researchers to understand reality rather than explain it (Mack, 2010).

The Pragmatic paradigm emerged in the late 19th century based on the work of John Dewey (Maxy, 2003; Stoilescu, McDougall, & Egodawatte, 2016). The Pragmatic paradigm allows the researcher to choose the most suitable methods to meet the requirements of the research proposal and not simply to seek the what but also the how (Creswell, 2009). Morgan (2014) emphasised that the pragmatic paradigm supports the ideas of how the cultural, historical, and political context might influence the research community. Thus, it encourages research that addresses the full range of questions that are of interest in the social sciences. In social science and education literature the notion of pragmatism is used as a theory of knowledge (Maxy, 2003), in the sense that pragmatism sees knowledge as the product or outcome of empirical inquiry. Johnson and
Onwuegbuzie (2004, p. 17) have described the paradigm of mixed method research as a “third wave or the third research movement, a movement that moves past the paradigm wars by offering a logical and practical alternative. Philosophically, mixed method research makes use of the pragmatic method and system of philosophy.”

4.1.2 Personal positioning

A research paradigm or, as it may be called, ‘worldview’, can be shaped by a researcher’s education background, experience, advisers and the field of study, all of which lead to the researcher’s choice of approach (Creswell, 2009). My position in this research as a student researcher, and in particular, the influence of my sociocultural and educational background and experience, has impacted my choice and implementation of this study’s methodological framework. My personal background of Middle Eastern Islamic culture, my experience as a resident of Jeddah, Saudi Arabia’s most multicultural city, and my training as a physics teacher, all shaped my understanding of the importance of learning and teaching science. My Master’s degree study in Australia, along with my experiences as a mother of two children studying in Australian schools, expanded my perspective on science teaching and learning in the context of Western education. All this sharpened my focus on issues of science literacy and language, and prompted the question of whether the experiences of learners with the English language used in science textbooks in Australia might have parallels in the Saudi context.

From the perspective of my ontological beliefs and perceptions of reality and epistemological beliefs about knowledge, it became clear to me that only a mixed methods approach would address my central concerns and questions about how learners of science engage with the language of their instructional materials. The research goals
of measuring Saudi students’ difficulty level in reading their Arabic language physics textbook, and identifying likely causes of this, was chosen as a specific avenue for exploring those central concerns. In measuring the difficulty level my approach was quantitative; however, I found that to gain a deeper understanding of this situation, the teachers’ views toward the textbook needed to be included. To do this I employed a qualitative approach to underpin my research investigation. This illustrates the way in which the pragmatic paradigm underpins my study (Creswell, 2009; Patton, 1990).

4.2 Mixed method research design

This section begins with an explanation of the overall research design and its mixed methods approach, before detailing how each method was applied. The two sections that follow this overview provide details regarding the quantitative and qualitative methods used: instruments, sample size, data collection procedures, and data analysis.

The most common purposes of social research are to explore, describe and explain a phenomenon (Babbie, 2013). Explanation often requires comparison and this can require numerical data produced by quantitative research. The numbers produced by quantitative research can measure perception and opinion through participant response to survey items, or they can measure knowledge and skills through participant response to test items (Lewin, 2005). This methodology aims to test a theory deductively and expose relationships between the factors being considered (Carr, 1994). Quantitative research is fundamentally concerned with comparison as a path to understanding, while qualitative research sees rich description as a path to the same end. Qualitative researchers consider deep description to be valuable to the social world (Denzin & Lincoln, 2008; Patton, 1990), involving ‘express commitment to viewing events, action, norms, values’
(Bryman, 1998, p. 61) to develop particular research theory inductively (Carr, 1994). The more time consuming a mixed methods approach provides a more comprehensive view of research problems (Denscombe, 2007).

For this study, quantitative data were needed in order to establish whether there were indeed any challenges posed for Saudi learners by the language of their physics textbook, and whether any such challenges were comparable to those faced by English speaking learners of science. Linguistic analysis of the text was needed to identify potential sources of such difficulties, and further quantitative data were then required to pinpoint which features of the text were actually causing difficulty, and to what degree. Learner demographics were also compared to assess possible influences from background variables such as prior knowledge and parental education levels.

A mixed methods approach provides different research designs that can be adapted to meet the target research requirements, including convergent parallel, explanatory sequential, exploratory sequential, embedded, transformative or multiple phase approaches (Creswell & Miller, 2000; Creswell, Plano Clark, Gutmann, & Hanson, 2003). This research followed the explanatory sequential design, as the quantitative and qualitative data were collected separately.

Once the extent and nature of learner difficulty with the Physics text had been established quantitatively, a deeper exploration of teacher and learner perceptions of the text, within its broader educational context, was possible using qualitative methods.

4.2.1 Conceptual design of the study
The following flowchart and the summary Table 4.3 at the end of this chapter show the place in the research design of each of the parts of this study: an initial online survey, a linguistic analysis of text features, a pilot cloze test study of reader difficulties, a larger cloze test study, a student questionnaire, and interviews with teachers. The table also indicates which of the research questions were addressed by each part of the study, and which published papers and other chapters relate to each part.

Figure 4.1: Flowchart for the conduct of this study based on Creswell (2012)

4.2.2 Ethical procedures of sampling and data gathering

This research was approved by the Human Research Ethics Committee at the University of Newcastle (ref. H-2014-0163) see Appendix C. Research approval was also granted by the Saudi Cultural Mission in Canberra and from the Ministry of Education in Saudi Arabia. Following this, the first step was to visit the Directorate of Education in Jeddah and Abha, (see Appendices N & O) which directed the researcher to the schools which had agreed to participate in the research. Consent forms were distributed to the school principals, teachers and students to clarify the purpose and the process of data collection. After receiving the teachers’ agreement to participate in this study, the surveys and interviews were conducted and recorded in accord with the ethics requirements.
For the expert judgement online survey of Arabic teachers, modified snowball sampling was used to distribute the link for the survey; participating teachers of Arabic passed the survey link on to colleagues, who were free to use it or not. Further description of the research procedure for this phase is provided in Chapter 5.

In the pilot study, after all approvals had been granted, the researcher visited each school in the first week after a one-week midterm holiday. In each of the three schools, a total of 80 students completed the test. Further description is provided in Chapter 6.

For the full study, the researcher spent three months in Saudi Arabia travelling between Jeddah and Abha, spending six weeks in each city. The study was carried out in three schools in each city. In each of these three schools, two classes were selected; each pair of classes had the same Physics teacher. Thus a total of six classes in each city were included, with three Physics teachers in each city. A total of 360 students completed both test and questionnaire. The process of collecting the data involved visiting each class for one lesson period, explaining to students the requirements of the test, and then allowing them to begin. The survey questionnaire was administered on a second visit to each class. The last step of collecting data was an interview with each teacher. These steps were followed in each participating school in each city, as further described in Chapter 7 (see Appendices D to M).

The researcher interviewed all six of the participating teachers in Arabic. The interview protocol comprised open-ended questions designed to enable the researcher to extract relevant information from participant responses. Most of the questions were intended to focus on the textbook and how teachers dealt with it. Teachers were asked about their teaching experiences, their own attitude toward the old and new curricula, teaching tools,
the challenges they faced during teaching, and how they coped with the new pedagogies, training and preparation. Each interview took between 20-30 minutes (as recommended by Schwandt, 2001). The interview transcripts were translated from Arabic to English by the researcher, and independently checked by another well-qualified bilingual Arabic speaker. A thematic framework was developed to guide the analysis, as described more fully in Chapter 8. Pseudonyms were used throughout the study to protect participant confidentiality; they were differentiated by naming them as Teacher 1 and Teacher 2 and so on.

4.3 The quantitative investigations

Quantitative methods were employed in the first three phases of the investigation:

- **Expert Judgement Analysis** was applied to compare estimated readability levels of samples of Arabic language instructional text from four Saudi Year 10 textbooks in different subject areas, in order to establish whether the Physics textbook might be especially challenging for readers (Chapter 5, addressing Research Questions 1 and 2). Participants were 94 experienced Saudi teachers, who rated perceived readability on a five-point scale.

- **A pilot study** using a cloze test was conducted to measure reading difficulties encountered by 80 Year 10 students in a selected passage from their mandatory Physics textbook; to identify which language features posed more difficulties than others; and to compare their level of reading difficulty with prior results from English speakers of similar age (Chapter 6, addressing Research Questions 3 to 5).
• **A larger cloze-based study** was conducted with 360 Year 10 students to measure relationships between reading difficulty and specific linguistic features of a Physics textbook passage, and to compare these results across background variables of prior knowledge, parental education levels, student age and nationality (Chapters 7 and 9, addressing Research Questions 4 and 6).

• **A survey questionnaire** was administered to the same 360 student participants, consisting of 48 items grouped into five conceptual scales: student learning personality, and attitudes towards their teachers, the Physics curriculum, their school, and learning in general. This enabled comparison between these factors and the cloze test scores (Chapter 9, addressing Research Questions 4 and 6). Factor analysis also enabled comparison of these results with themes emerging from the qualitative interview data (Chapter 8, addressing Research Question 7).

This section gives an overall description of the methods used for these investigations, while aiming to minimise repetition of the methodology sections of the four published papers.

### 4.3.1 Survey procedures

Surveys gather systematic sets of data (*variables*) and measure the relationship between at least two or more variables; the questionnaire is the most popular survey technique (Bryman, 2001; De Vaus, 2002). Surveys are used as tools to clarify the research assumptions (Bryman, 1984). Surveys allow the researcher to ask the same question for a large number of people (Neuman, 2006). This section explains the quantitative instruments that were used in this research.
• First, an anonymous online survey of teachers with expertise in Arabic language was constructed to compare the language of the Physics textbook with other Year 10 textbooks, in order to establish the degree of familiarity that such students might be expected to have with the style of Arabic used in their Physics textbook. This expert judgement analysis was completed by 94 experienced Saudi teachers of the Arabic language. The teachers were asked to assess passages extracted from Year 10 textbooks, including Physics, rating each passage on a five point scale from easier to more difficult for Year 10 students to read, as described in Chapter 5.

• Second, a cloze test was designed for the pilot study of 80 Year 10 students from three schools in Abha. This test was constructed by applying a cloze procedure to a selection of passages across three pages from the Physics textbook. The length of the combined extract was between 250-300 words. Every fifth word of the passage was deleted and the first sentence was left intact. A total of 50 words were deleted. Students were required to read the passage and fill in the gaps. This pilot test proved effective in allowing the researcher to measure the level of reading difficulty for these students, as described in Chapter 6.

• Third, another cloze test was developed for the full study, with 360 Year 10 students drawn from two cities, Jeddah and Abha, from three classes in each of three schools in each city. The cloze test was based on the mandatory Physics textbook and was constructed by choosing one authentic page of 250-300 words from the textbook. As for the pilot study, the researcher deleted every fifth word leaving the first sentence intact with a total of 50 gaps. This test was completed by the participating students. The research was conducted before the students had reached this section.
of the textbook, except for one class which had already taken the lesson before performing the cloze. More details are given in Chapter 7.

Cloze test results are most often used to determine the readability of a text for a particular group of readers and this involves counting the number of gaps correctly filled and comparing the average total with criterion scores. This was the focus of previous work in Arabic that used cloze tests (for example, Al-Matrafi, 2010; Ktait, 2002). The present study took a new and different approach: individual items deleted in the cloze test were categorised and the words that students entered to fill the gaps were analysed in order to reveal patterns of student difficulty with the particular passage (O’Toole, Cheng, & O’Toole, 2015). It found that the analysis of participant conceptual replacement of deleted items to reveal patterns of reader difficulty is valid.

In designing the cloze test instrument, the use of grammatical affixes and clitics in Arabic text raises the question of what constitutes an Arabic ‘word’ for the purposes of cloze deletion. Hofman and Habib-Allah (1982, p. 276) point out that affixes to an Arabic word may include prepositions, possessive pronouns, definite articles, conjunctions, subject and object pronouns; all of which could be considered as separate words in other languages. In the pilot study the researcher separated the prefix or suffix from the base words and counted each of these morphemes as a single word. However, earlier reading research in Arabic had followed the established English approach, counting anything separated by white spaces as a ‘word’ and analysing it accordingly (Al-Matrafi, 2010; Hofman & Habib-Allah, 1982; Sesi, 1982; Toiemah, 1978) and the full study did likewise.
The researcher thus modified the deletion procedure by including any word separated by white spaces. The student entries were coded as exactly correct, conceptually correct, and clearly wrong or defeat. The ‘defeat’ coding was used after a student had stopped entering suggestions for the deleted words. This removed the possibility of misinterpreting lack of response as a mistake once a student had stopped attempting entering suggestions. The researcher tested the students in one period of 45 minutes in the Saudi Arabian school day which was sufficient for the students to complete the cloze test.

The language features were coded as representing parts of speech according to traditional Arabic grammar (noun, verb, and so on) and also as representing different degrees of ‘technicality’. Words unique to Physics are coded ‘Technical’; everyday Arabic words are coded ‘Non-technical’; and words that are used in everyday language but have a specific meaning in Physics are coded ‘Semi-technical’. The same word was categorised twice. So, deletions could represent a ‘Technical Noun’ (e.g. ‘scales’ in the sense of the laboratory apparatus for measuring weight) or a ‘Semi-technical Adjective’ (e.g. ‘free’ in the sense of not encountering resistance); and the counts for the technical categories cannot be added to the counts for dictionary categories.

- Fourth, a student survey questionnaire was used to gather background detail on each student. The questionnaire was designed with closed questions to cover the relevant demographic and learning disposition categories (Pallant, 2005). This enabled the attitudinal details provided by each of the respondents to be correlated with the cloze test results to determine connections between student characteristics and difficulties with the language of their Physics textbook, as described in Chapters 7 and 9. Moreover the student responses were triangulated with teacher interview results, as described in Chapters 8 and 9.
The first part of the questionnaire included student background information: Age, place of birth, nationality, whether they had studied abroad, and their parents’ levels of education. The second part comprised five different conceptual scales, each of ten or nine items with a total of 48 items. These scales included: student learning personality, attitude toward teachers, attitude toward Physics curriculum, and attitude toward school and finally their attitude toward learning in general. The questions were not grouped by scale but were divided into two schedules according to whether they elicited agreement or frequency data (see Appendix GG). The response format of the questionnaire was a Likert scale of six to allow the research a wide range of scores to enhance the data analysis (De Vaus, 2002; Pallant, 2005). The survey took students around 20 to 30 minutes to complete.

4.3.2 Validity

The general definition of validity is “the property of a measure that allows the researcher to say that the instrument measures what he says it measures” (Hammersley, 1987, p. 73). Assessing validity can be achieved through various measurement tools based on the researchers’ requirements at each stage of the research (Winter, 2000). Validity in quantitative research is defined as the extent and accuracy of measurement of specific variables in the study (Heale & Twycross, 2015). The purpose of assessing validity is to confirm that the instrument covers the entire range of research data which it is designed to measure (Creswell, 2012; Heale & Twycross, 2015). The four main aspects of validity to be considered are: content validity (Bryman, 2001; Roberts, Priest, & Traynor, 2006); criterion validity; construct validity (Pallant, 2005); and face validity (Bryman, 2001).
The validity of using a cloze test as a tool of measuring readability in the Arabic language has been confirmed in several previous studies (for example, Houston et al., 1987; Toiemah, 1978). To enhance the validity of the quantitative methods employed here, different strategies have been applied at each stage of the research. Table 4.1 clarifies each type of validity in relation to each of the quantitative instruments.

Table 4.1: Validity

<table>
<thead>
<tr>
<th>Research tools</th>
<th>Type of Validity</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Online Survey</strong>&lt;br&gt;Expert judgement</td>
<td>Content Validity</td>
<td>Authentic Year 10 textbook extracts, selected from different subjects studied by the target group across varied disciplines. Online survey was pre-tested with three Arabic language experts to improve validity of text selection.</td>
</tr>
<tr>
<td>Face Validity</td>
<td>Expert judgement in ranking reading difficulty in Arabic previously established (Al-Heeti, 1984; Houston et al., 1987).</td>
<td></td>
</tr>
<tr>
<td>Criterion/concurrent Validity</td>
<td>Validity of this Delphi-like technique for arriving at a consensus of experts through their independent rankings for specific things has been established across a wide range of research (Clayton, 1997).</td>
<td></td>
</tr>
<tr>
<td>Construct Validity</td>
<td>Arabic experts judged the Physics passage as the harder one, as the theoretical construct predicted.</td>
<td></td>
</tr>
<tr>
<td><strong>Pilot study</strong>&lt;br&gt;Cloze test</td>
<td>Content Validity</td>
<td>Authentic passages from the Physics textbook, selected by experienced Arabic speakers.</td>
</tr>
<tr>
<td>Face Validity</td>
<td>Participants understood the test task and responded in proportion to their level of reading difficulty with the text.</td>
<td></td>
</tr>
<tr>
<td>Criterion Validity</td>
<td>Participant scores showed agreement with Arabic language experts’ predictions of text difficulty.</td>
<td></td>
</tr>
<tr>
<td>Construct Validity</td>
<td>Results patterned similarly to those from previous studies measuring Arabic readability.</td>
<td></td>
</tr>
<tr>
<td>Research tools</td>
<td>Type of Validity</td>
<td>Evidence</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Full study</strong></td>
<td>Content Validity</td>
<td>Authentic passage from mandatory Year 10 Physics textbook (Rafee, Hadad, Sabag, &amp; Alorani, 2014, p. 105).</td>
</tr>
<tr>
<td>Cloze test</td>
<td>Face Validity</td>
<td>Inability to provide conceptually correct words to fill text gaps left by regular deletion appears connected with student difficulty in reading such text.</td>
</tr>
<tr>
<td></td>
<td>Criterion Validity</td>
<td>Cloze tests produce readability scores similar to those generated by Pilot Study.</td>
</tr>
<tr>
<td></td>
<td>Construct Validity</td>
<td>Deletions were categorised in ways that match the conventions of Arabic grammar.</td>
</tr>
<tr>
<td><strong>Student Survey</strong></td>
<td>Content Validity</td>
<td>Survey was developed by the researchers and two expert educators and revised with an Arabic language expert and a Saudi PhD student studying in Newcastle.</td>
</tr>
<tr>
<td></td>
<td>Face Validity</td>
<td>Survey results gave a clear indication of student attitudes toward the recent textbook reform.</td>
</tr>
<tr>
<td></td>
<td>Criterion Validity</td>
<td>Final results of the survey analysis showed a pattern of agreement with the cloze test results.</td>
</tr>
<tr>
<td></td>
<td>Construct Validity</td>
<td>Correlations between student test results and survey responses were as predicted theoretically.</td>
</tr>
</tbody>
</table>

### 4.3.3 Reliability

Reliability “refer(s) to the capacity of a measure to produce consistent results” (Blaikie, 2003, p. 219). One of the important aspects of determining reliability is by measuring internal consistency, commonly through use of Cronbach’s alpha coefficient (Bryman, 2001; Johnson & Christensen, 2012; Pallant, 2005). Cronbach’s α ranges between 0 and 1, with the result closest to 1 indicating the greatest internal consistency (Gliem & Gliem, 2003). George & Mallery (2000) suggest the following criterion points for Cronbach’s α

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values: > 0.9 Excellent; > 0.8 Good; > 0.7 Acceptable; > 0.6 Questionable; > 0.5 Poor; and < 0.5 Unacceptable. In this study 0.7 and above was considered as acceptable; however, in the language feature sub-test, features with Cronbach’s α values greater than 0.5 have been treated as worth discussing (following Hinton, McMurray, & Brownlow 2004, p. 363). Table 4.2 summarises Cronbach’s α values for the research instruments, results of which are analysed in more detail in the following chapters.

Table 4.2: Cronbach’s alpha

<table>
<thead>
<tr>
<th>Test</th>
<th>No of items (1)</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloze test one (Pilot Study)</td>
<td>50</td>
<td>0.964</td>
</tr>
<tr>
<td><strong>Subtest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noun</td>
<td>18</td>
<td>0.877</td>
</tr>
<tr>
<td>Pronoun</td>
<td>2</td>
<td>0.696</td>
</tr>
<tr>
<td>Verb</td>
<td>9</td>
<td>0.781</td>
</tr>
<tr>
<td>Adverb</td>
<td>7</td>
<td>0.653</td>
</tr>
<tr>
<td>Conjunction</td>
<td>8</td>
<td>0.547</td>
</tr>
<tr>
<td>Preposition</td>
<td>4</td>
<td>0.513</td>
</tr>
<tr>
<td>Technicality</td>
<td>22</td>
<td>0.892</td>
</tr>
<tr>
<td>Cloze test two (Full Study)</td>
<td>50</td>
<td>.896</td>
</tr>
<tr>
<td><strong>Subtest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noun</td>
<td>13</td>
<td>.682</td>
</tr>
<tr>
<td>Preposition</td>
<td>7</td>
<td>0.690</td>
</tr>
<tr>
<td>Technical</td>
<td>9</td>
<td>0.586</td>
</tr>
<tr>
<td>Semi-technical</td>
<td>11</td>
<td>0.582</td>
</tr>
<tr>
<td>Non-technical</td>
<td>30</td>
<td>.855</td>
</tr>
<tr>
<td>Student Questionnaire</td>
<td>48</td>
<td>.832</td>
</tr>
</tbody>
</table>

Key:

1 Each test had 50 items but the results for a subtest are only reported if it contained more than three items and if its reliability was greater than α = 0.5. The frequency of correct responses was counted twice, once for Technicality and once for the other categories.
4.4 The qualitative investigation

The reason for choosing to approach research through a qualitative method is to gain understanding of a particular natural phenomenon (Berg, 1995). This requires developing questions and appropriate methods for seeking answers to them. In qualitative research, the researcher and their participants are regarded as the main tools when collecting data (Flick, 1998). The interview is the most common method used in qualitative research (Minichiello, Aroni, & Hays, 2008) especially in the field of Education (Tierney & Dilley, 2002). In-depth-interview methods can provide us with the most authentic data through conversational interactions (Dunne, Pryor, & Yates, 2005). A strength of using interviews is that it opens the way to direct contact with a participant to gather the data (Cohen, Manion, & Morrison, 2011). The relationship of the qualitative investigation to the overall conceptual design of this research is shown in Section 4.2.1.

4.4.1 Interview procedures

This part of the research deployed in-depth interviews. To investigate teacher perceptions of the textbook, and of language use in Saudi Physics classes, a semi-structured interview protocol was developed consisting of open-ended questions designed to enable the researcher to extract relevant information. An advantage of using the semi-structured interview is that the researcher is enabled to seek deeper information in comparison to other methods such as survey and focus group (Johnson, 2002). A semi-structured interview allows the flexibility to structure the level of control (Minichiello et al., 2008), permitting the interviewer to follow up questions and gather a large amount of information (Marshall & Rossman, 2014).
Most of these questions centered on the textbook and how teachers dealt with it. Teachers were asked about their teaching experiences, their own attitude toward the old and new curricula, the teaching tools and resources they used, the challenges they faced during teaching, and how they coped with the new pedagogies, training and preparation. The interview questions were grouped under three topics: syllabus, resources, and language; each topic had two or three questions with a total of eight questions; follow-up questions and prompts were used to clarify, expand and keep the responses on track.

Interviews have to be transcribed, in order to transform oral data into written language data whether the interview is being conducted via audio or video recording (Roulston, 2014). Kvale (1996) has asserted that the quality of the authentic raw data of interviews is crucial for the next steps of quality analysis, verification and reporting. Richards (2005) confirmed that interpretation is essential and depends on the researcher to gain reliable data. In the analysis stage, the researcher has to re-read the interview transcript and note particular themes developing from the data. The interview transcripts were translated from Arabic to English language by the researcher, and independently checked by another well-qualified Arabic speaker. The development of a thematic framework to guide the analysis is described more fully in Chapter 8.

4.4.2 Validity

The quality of qualitative research, similar to quantitative research, can be evaluated by applying concepts or dimensions of validity. A central theme in discussions of validity in qualitative research is that it has to be applied according to the specific goals of the research (Mays & Pope, 2000). According to Silverman (2013) validity at its base element is trust. Mishler (1990) stresses that researchers need to give sufficient information in
order to engender ‘trustworthiness’ in their work and so that other researchers can perceive the researcher’s future research as being truthful and dependable.

In qualitative research validity functions as “a lens not based on scores, instruments, or research designs but a lens established using the views of people who conduct, participate in, or read and review a study” (Creswell & Miller, 2000, p. 125). Rolfe (2006) draws attention to conflicting points of view around whether a specific validity framework is needed in qualitative research or not. The latter viewpoint considers that such a framework “should be abandoned in favour of individual judgements of individual studies” (p. 309). Along this line, validity can also be defined as “a goal rather than a product; it is never something that can be proven or taken for granted” (Maxwell, 1992, p. 86). Freeman, Preissle, Roulston, and Pierre (2007, p. 27) articulate that “we focus on validity as characteristic of the standard of evidence discourse as it relates to qualitative inquiry”. A central feature underlying these validity concepts, as Cakir (2012) indicates, is that validity does not equate with facts or even truth per se. These various perspectives are generally in alignment with Winter’s (2000) assertion that the measure of validity cannot be absolute but should be determined according to researchers’ decisions on what stage of the research process needs to be validated (Winter, 2000).

Creswell and Miller (2000) suggest that different validity procedures might be applicable for qualitative methods than for other procedures. They list these as: member checking, triangulation, thick description, peer reviews, and external audit. Researchers might employ more than one of these procedures to increase their research validity with regard to the research results. To enhance validity in the present study, triangulation was employed between the quantitative results based on student questionnaires and the teacher
interview results (further details are available in Chapter 8). Triangulation requires integrating and comparing data gathering from both qualitative and quantitative methods (Gibson & Brown, 2009; Patton, 1990). Numerous researchers advocate the use of triangulation as increasing the level of validity (Golafshani, 2003; Major & Savin-Baden, 2010; Mathison, 1988; Maxwell, 1996; Patton, 1990), especially in mixed methods research.

Of the other procedures, member checking, in the sense of eliciting participant feedback on the research, was not attempted formally; but interviewees’ informal comments to the researcher reflected positively on the content of the interview questions, and on the opportunity for teachers to voice their opinions on these matters. Incorporating the voices of participants through extracts from interviews in the reporting of the research (in Chapter 8) is a step toward “thick description”, as noted by Ponterotta (2006, p. 547). Peer review of the research was applied as part of the University’s Research Ethics approval procedure, prior to data collection. A degree of external audit is provided via the process of review for the refereed journal papers, and via evaluation of the PhD thesis by external examiners.

4.5 Summary of methodological design

To conclude this explanation of the study’s methodology, the data collection procedures are mapped in relation to the research questions in the following Table 4.3. It may also be helpful to refer back to the flowchart, Figure 4.1 in section 4.2.1.
### Table 4.3: Summary of data collection procedures and research questions

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Source of data</th>
<th>Type of data</th>
<th>Data analysis</th>
<th>Data location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do text samples drawn from textbooks for a range of Saudi Year 10 subjects differ in readability?</td>
<td>Online survey comparing text passages, Experts’ ratings</td>
<td>Ratings by 94 Saudi expert teachers of Arabic</td>
<td>SPSS 23.0, significance testing</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>2. Do experts in Arabic language rate Year 10 Saudi science text as relatively hard for students to read?</td>
<td>Cloze test, Linguistic analysis of deleted cloze items</td>
<td>Test results from 80 Year 10 students from Abha city, Linguistic analysis by the researchers. Test results from 360 students in Abha and Jeddah, Comparable findings from past and present studies</td>
<td>SPSS 23.0, significance testing, Traditional and functional linguistic categories, Comparison of findings</td>
<td>Chapter 6, 7</td>
</tr>
<tr>
<td>3. Do some Saudi students have trouble in reading a mandatory science textbook?</td>
<td>Cloze test, Linguistic analysis of deleted cloze items</td>
<td>Test results from 80 Year 10 students from Abha city, Linguistic analysis by the researchers. Test results from 360 students in Abha and Jeddah, Comparable findings from past and present studies</td>
<td>SPSS 23.0, significance testing, Traditional and functional linguistic categories, Comparison of findings</td>
<td>Chapter 6, 7</td>
</tr>
<tr>
<td>4. Does close linguistic analysis of Saudi student replacement of regular deletions from an authentic physics text reveal a pattern of language difficulty?</td>
<td>cloze test and student questionnaire, Teacher interviews and student questionnaire</td>
<td>Test results and survey responses from 360 students in Abha and Jeddah, 6 teacher interviews, 360 student surveys</td>
<td>SPSS factor analysis, Thematic analysis of interview data and student survey data</td>
<td>Chapter 9, 8</td>
</tr>
<tr>
<td>5. Does any such pattern match existing data on the problems faced by English-speaking students with the language of their science books?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6. How do prior knowledge, language variety and parental education influence student performance when reading?</td>
<td></td>
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<tr>
<td>7. What are the teachers’ and learners’ perceptions of the latest Saudi science education reform with specific relation to physics, particularly in terms of the style of written language in the textbook and of the new teaching strategies that are required?</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Chapter 5: Teacher-perceived readability of Saudi school texts

Originally published:

Abstract

A sample of passages from mandatory Year 10 textbooks in Saudi Arabian schools were rated by 94 experienced Saudi teachers of the Arabic language, on a five point scale of perceived reading difficulty for Year 10 students. This application of Expert Judgement Analysis enabled comparison of estimated readability levels across school subjects, confirming that in Arabic, as in English, text difficulty varies across differing subject matter, and suggesting that textbook readability in Arabic may impact student comprehension of the subject matter, as has been found in English-medium contexts. Over half of these expert readers rated the Physics text as the hardest to read of the sample passages. These findings point to a need for further research into the elements of science text that could cause difficulty for students in such contexts.

Keywords: readability, expert judgement analysis, literacy, science education

5.1 Introduction

This paper represents the first stage in an investigation of the difficulty that Physics texts pose for secondary students in Saudi Arabia. The overall study has implications for the way reading in Arabic is conceptualised and taught across the Islamic world. Arabic is the medium of instruction in many parts of the MENA (Middle East and North Africa) region and the language of religious instruction more widely. This wider impact suggests
that the relative difficulty of Physics texts may be an important preliminary question. How do Arabic teachers, who are expert readers of Arabic, evaluate the difficulty of Physics texts against other literature adolescents are expected to read in that language?

Reading is more than the ability to sound out a text; it also requires deep comprehension of that text (Al-Alwan, 2012). Norris and Phillips (2003) affirm this need for comprehension in the context of scientific English, stating that it is the key for access to scientific knowledge. Further to this, Gallagher, Fazio, and Gunning (2012) assert that basic reading difficulties can impede understanding of scientific text and consequently make learning more difficult. As Trowbridge, Bybee, and Powell (2000) point out, it is important that specialist material should be appropriate to the reading level of the students. The middle years of schooling confront adolescent pupils with an increasing variety of texts specific to their various school subjects, yet pupils are not necessarily aware of differences between genres, such as between scientific and literary texts. The present research aims to identify any differences in perceived reading difficulty between samples of Physics and other texts selected from Year 10 textbooks used throughout the Saudi school system, where Arabic is the medium of instruction.

5.2 A pivotal point in Saudi education

Year 10 is a critical point in the Saudi education system. It is the first year of secondary school, following six years at elementary and three at intermediate level. The secondary level consists of six semesters, taught over three years (10-12). Year 10 provides consolidated general preparation, after which learners choose one of three specialised tracks (scientific, literary or administrative) to study in Years 11-12, in preparation for completion of the secondary level certificate (Ministry of Education, 2015). The present
initial examination of school texts begins with Year 10 learning materials because difficulties experienced at this time will have great influence on subsequent choice of a student’s secondary track. Most students who obtain a high score in Science and Mathematics subjects are likely to join the scientific stream (Alqarni, 2015); hence the focus in this research is on the difficulty of texts that learners encounter as they prepare to choose the track they will subsequently follow.

The Saudi Ministry of Education provides textbooks for all school subjects and both students and teachers consider these mandated texts to be the main resource for teaching and learning. The new science curriculum that has been recently adopted in Saudi Arabia is different from that previously in place. Education experts such as Al-Mazroa and Al-Shamrani (2015) assert that the success of the science education reform movement will depend on teachers applying appropriate teaching strategies and shifting their traditional teaching style to be more compatible with the current reformed curriculum. However, it is highly likely that implementation of the new curriculum will greatly depend on the ease with which students can access their new textbooks, which raises the issue of the readability of those Arabic science texts.

5.3 Estimating readability

‘Readability’ is an attempt to quantify such difficulties, and rests on reader ability to deal with both text structure and characteristic language features (O’Toole & King, 2010). The perceived complexity of any text relies on two factors: the reader and the text (Oakland & Lane, 2004). Prior estimates of text readability could be very useful to teachers choosing instructional material, and authors and publishers who prepare it. Readability in English has been of much interest since 1920 (Islam, Mehler, & Rahman, 2012), with
considerable interest in readability formulas that yield a quantified estimate that can be matched with a school grade (Chall & Dale, 1995b; Fry, 1977; Gilliland, 1972). The various elements of text, such as vocabulary, length, format, word repetition, and illustrations, have long been grouped into different levels, the perceived difficulty of which led to their quantification into different readability formulas. Formulas for English has drawn on interaction of word and sentence length, or comparison with a list of frequently used words from an existing language corpus.

Readability of different texts has been estimated in a variety of ways, including readability formulas like those mentioned above; cloze tests; comparison with standard texts; and teacher and other expert judgments (Al-Khalifa & Al-Ajlan, 2010; Hiebert, 2012). Some readability experts have suggested that subjective levelling should accompany the use of the readability formula (DuBay, 2004). For example, Chall and her co-workers provided a set of scales for the grading of passages as a practical guide for both teachers and writers. They provided 52 different samples representing a variety of text types (literature, popular fiction, life science, physical science, narrative social studies and expository social studies) that were scaled according to what they require of the reader, in terms of “language, sentence length and complexity, conceptual difficulty and idea density and difficulty” (Chall, Bissex, Conard, & Harris-Sharples, 1996, pp. 15,16). This approach, together with the results of the application of the various readability formulas for which it supplies an alternative, demonstrates the existence of variations in language difficulty in texts from different parts of the school curriculum. Each discipline apparently has its own set of clearly defined linguistic features in English, and this can provide differing degrees of difficulty for learners attempting to use them (Shanahan, Shanahan, & Misischia, 2011).
5.4 Readability of textbooks in Arabic

There has been less work on readability in Arabic, although the field has aroused more scholarly interest in recent years (Al-Khalifa & Al-Ajlan, 2010; Al-Tamimi, Jaradat, Aljarrah, & Ghanem, 2013; Cavalli-Sforza, El Mezouar, & Saddiki, 2014). The readability of Arabic texts has been investigated through use of the gap-filling cloze tests, corpus comparison, and readability formulas emerging from either or both. Dawood (1977) was cited by Al-Heeti (1984) as paving the way for research into the levels of readability of Arabic texts. Dawood took 30 passages from an Iraqi textbook in Arabic and constructed cloze tests from them. These cloze tests were completed by 360 fifth grade students and their entries were analysed to identify linguistic variables within Arabic that could be used as predictors of reader success. He examined five linguistic variables: average word length in letters, average sentence length in words, average word repetition, percentage of sentences beginning with a noun, and percentage of definite nouns. Correlation analysis indicated that average word length in letters, average sentence length in words, and average word repetition were the most highly significant predictor variables. Al-Heeti (1984) subsequently used the judgement of experts (Judgement ANalysis: JAN) to refine Dawood’s readability formula for the Arabic language. Al-Heeti asked 15 teachers to score 60 Arabic passages from elementary schools (Year 1 to Year 6). The teachers were given 6-point scales on which to assess 10 passages for each point, ranging from the 10 easiest passages deemed for Year 1 level to the 10 hardest passages, appropriate for Year 6. Al-Heeti used the scores provided by the judges as criterion points for comparison with analysis of the passages according to Dawood’s variables. Al-Heeti determined that ‘average word length’ (AWL) correlated most strongly with rankings by the 15 teachers participating in his study ($r = 0.94$). Al-Heeti suggested the readability
formula for Arabic that appears below. The single variable (AWL) emerged from correlation and the constants (4.414 and 13.468) from multiple regression calculations.

“Grade Level = (Average Word Length x 4.414) – 13.468” (Al-Heeti, 1984, p. 102)

This use of expert opinion (JAN) was extended, by use of ranked judgements (Houston, Al-Heeti, & Al-Harby, 1987) with calculated multiple regression (Houston, 1974), to produce Judgement Analysis paired comparison (JAN-PC) to make reliable and valid comparison of relative text difficulty, and this approach was subsequently supported by Miller and Salkind (2002). Houston and his co-workers asked five expert teachers of Arabic to act as judges to rank Al-Heeti’s 15 passages by reading difficulty, and compared this with the five linguistic variable scores at the predicted criterion values. The results were consistent with Al-Heeti’s earlier work. Al-Heeti’s formula was later correlated with results from a cloze test to assess the validity of a checklist developed as guide to the readability of textbooks in Arabic, yielding a correlation of 0.87 between Al-Heeti’s formula and the checklist (Al-Mekhlafy, 1988).

In 2010 Al-Khalifa and Al-Ajlan analysed documents from a corpus collected from Saudi Arabian textbooks for primary, intermediate and secondary levels. The corpus contained 150 documents comprising 50 documents from each level, consisting of 57,089 tokens in all. Their corpus analysis focused on five linguistic features: average sentence length, average word length, average number of syllables per word, word frequencies, and language model (LM). Their results suggest that a combination of word frequency (WF), average sentence length (ASL) and statistical language model (SM) grants the most impact for the readability classification process. These documents were correlated according to school level and text difficulty: the easy text level matched with the primary
school, the medium text difficulty level for the intermediate school and the most difficult text level related to the secondary school. The researchers then verified the reliability of their prototype by asking three linguistics experts from Princess Norah University to examine the ranking of the 26 documents. The experts were unanimous in accurately matching the easy text with primary school, but their level of agreement was much lower in judging the medium text level (Al-Khalifa & Al-Ajlan, 2010). This work yielded a tool which was likely to be useful when choosing text for younger children but less applicable to intermediate/secondary school pupils.

A similar study worked from a corpus of 1196 Arabic texts from Jordanian textbooks in different subjects for classes from Grade 1 to Grade 10 (Al-Tamimi et al., 2013). This group considered the number of characters in text, number of words in text, number of sentences in text, number of difficult words in text, average word length, and average number of difficult words. Then they applied factor analysis to group variables for multiple regressions to yield a potentially useful readability formula. Number of characters (NOC), average characters per word (ACW) and average words per sentence (AWS) emerged from the factor analysis and regression to yield the following Arabic readability formula:

“AARIBase = (3.28×NOC)+(1.43×ACW)+(1.24×AWS)” (Al-Tamimi et al., 2013 p. 374)

In the course of a study of strategies used by native Arabic speakers when reading Arabic and English passages, Alsheikh and his assistant determined the level of readability of each passage. They used the Flesch Kincaid formula to estimate the difficulty of the English passage but, returning to JAN-PC, they used a group of experts to judge the readability of the Arabic passage (Alsheikh & Mokhtari, 2011).
There appears to be disagreement among those few researchers who have studied readability in Arabic, some preferring formulas emerging from corpus studies while others rely more on expert judgement. The present study will make careful use of both.

5.5 Technical Communication: ‘Reading in Science’

Oyoo (2012) suggests that the level of instructional language commonly used in science texts and in the classroom can affect the ability of students to understand scientific concepts. Koch (2001) has indicated that differences in style between the written language used in science texts and that used in other types of text necessitates different reading techniques, and that this involves reader understanding of the importance of seemingly non-essential words. Schleppegrell (2007) suggested that learning the language of a new discipline is ‘part and parcel’ of the learning of that particular discipline. Physics, Chemistry and Biology texts typically include photos and diagrams, and so it is also necessary to give attention to developing students’ visual skills if they are to read and comprehend such texts (Omar & Al-Otaibi, 2014).

Although the desirability of using the native language in learning and teaching is recognised in principle (Al-Qurashi, 1982), it is noticeable that the now mandatory Physics texts include new examples, new definitions and symbols that are written in English (see Appendix T). The success of the new Saudi science curriculum will be influenced by the ease with which pupils can access the new textbooks. This highlights the question of the language difficulty of those textbooks and provides the research questions for this paper:
1 Do text samples drawn from textbooks for a range of Saudi Year 10 classes differ in readability?

2 Do experts in Arabic language rate Year 10 Saudi science text as relatively hard for students to read?

5.6 Methodology

This study elicited Arabic teachers’ opinions regarding the relative difficulty of different subject texts through focus on Saudi mandatory secondary school textbooks for the Year 10 subjects: Biology, Geography, Arabic grammar and Physics (Ministry of Education, n.d.). These expert judgements were obtained by using a voluntary, anonymised snowball sampling method (Cohen, Manion, & Morrison, 2011) through a survey delivered to both male and female participants via Qualtrics survey software with the link distributed via email and the social media application ‘What’s App’. A request for teachers of Arabic to participate was distributed both through the app and via separate emails. The message identified the first author and contained a request for recipients to pass the message on to other Arabic teachers. The message contained a link to the survey on Qualtrics (See Appendix P).

An online survey has the advantage of collecting an extensive amount of data in a short period of time (Creswell, 2012), and can be easily distributed in different cities. Teachers of Arabic were recruited because they can be expected to recognise the relative difficulty of Arabic text.

The first part of the survey dealt with demographic questions of gender, years of teaching experience, stage of teaching (primary, intermediate and secondary) and previous
experience in teaching Year 10. The second part of the survey contained the four text passages. These were authentic passages each representing one page of the particular textbook, including any graphs and diagrams. As the unit of comparison was a single page, the total number of words in each passage varied between 148 and 275 words. Appendices P, Q, R, S and T present the survey and the sample passages of text. Table 5.1 contains the readabilities of the texts, under both the Al-Heeti and the Al Tamimi formulas (See Table 3.3) and aligned by a supposed school grade. The Al-Heeti formula has been used by a number of other researchers and so its use here allows comparison of these results with their work. The Al Tamimi formula is much more recent and based on analysis of a group of school texts, which makes it appropriate for this study.

Table 5.1: Text readabilities

<table>
<thead>
<tr>
<th>School grade</th>
<th>Al Tamimi estimate*</th>
<th>Text samples AARI estimate</th>
<th>Sample text subject of AARI</th>
<th>Al-Heeti formula readability#</th>
<th>Sample text subject of Al-Heeti</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>924.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1684.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1622.80</td>
<td>2626.92</td>
<td>Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2753.43</td>
<td>Geography</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3634.59</td>
<td>Arabic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4048.65</td>
<td>4054.45</td>
<td>Physics</td>
<td>5.954375 5.57702</td>
<td>Physics Arabic</td>
</tr>
<tr>
<td>6</td>
<td>4971.59</td>
<td></td>
<td></td>
<td>6.492828</td>
<td>Geography</td>
</tr>
<tr>
<td>7</td>
<td>8261.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>7950.64</td>
<td></td>
<td></td>
<td>8.833796</td>
<td>Biology</td>
</tr>
<tr>
<td>9</td>
<td>9093.762</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>9410.994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
* Based on Al-Tamimi et al. (2013, p. 375)
# Based on Al-Heeti (1984, p. 102)
Both formulas were reported as digitally available but access proved difficult and the calculations for this study were carried out manually.

One hundred and thirty-three people accessed the survey over a 12 day period, with a dropout rate of 3% unfinished attempts leaving 117 survey respondents (30 male and 87 female). Cleaning data by deleting respondents who did not complete the ranking of the passages left a total of 94 Arabic teachers (70 female and 24 male) as study participants.

### 5.7 Procedure

Participating Arabic teachers were asked to provide demographic details and then to read the text samples and rate the perceived difficulty for a Year 10 student of each passage, on a 1 to 5 scale: 1 very easy, 2 easy, 3 medium, 4 hard and 5 very hard. Data emerging from the survey was analysed via the SPSS program (version 23.0), initially to determine frequency of background demographics, then to indicate the perceived relative difficulty of the four passages before ranking their difficulty and exploring the interaction of participant backgrounds and estimates of Year 10 school text readability.

### 5.8 Results and discussion

The main purpose of this investigation was to draw on expert opinion to estimate the relative difficulty of four passages selected from Year 10 textbooks. The demographic information presented in Table 5.2 showed that a large majority of participants were females working in secondary schools, currently teaching Year 10, who had taught for more than a decade.
Table 5.2: Participants demographic details (data provided in survey responses)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Responses</th>
<th>Level</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>94</td>
<td>Male</td>
<td>24</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>70</td>
<td>74.5</td>
</tr>
<tr>
<td>Experience in teaching</td>
<td>91</td>
<td>Yes</td>
<td>60</td>
<td>63.8</td>
</tr>
<tr>
<td>Year 10</td>
<td></td>
<td>No</td>
<td>31</td>
<td>34.0</td>
</tr>
<tr>
<td>Level of school teaching</td>
<td>93</td>
<td>Primary</td>
<td>24</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intermediate</td>
<td>26</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Secondary</td>
<td>43</td>
<td>45.7</td>
</tr>
<tr>
<td>Teaching experience</td>
<td>87</td>
<td>1-10 years</td>
<td>25</td>
<td>28.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-20 years</td>
<td>42</td>
<td>48.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21-35 years</td>
<td>20</td>
<td>23.5</td>
</tr>
</tbody>
</table>

It might be expected that some of these background variables might influence the way that participants rated the difficulty of various text samples. Table 5.3 shows how the expert participants rated the difficulty of the four text samples.

Table 5.3: Level of perceived text difficulty based on subject

<table>
<thead>
<tr>
<th>Subject</th>
<th>Very Easy</th>
<th>Easy</th>
<th>Medium</th>
<th>Hard</th>
<th>Very Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>12</td>
<td>12.8</td>
<td>26</td>
<td>27.7</td>
<td>25</td>
</tr>
<tr>
<td>Geography</td>
<td>38</td>
<td>40.4</td>
<td>19</td>
<td>20.2</td>
<td>13</td>
</tr>
<tr>
<td>Arabic</td>
<td>30</td>
<td>31.9</td>
<td>20</td>
<td>21.3</td>
<td>17</td>
</tr>
<tr>
<td>Physics</td>
<td>12</td>
<td>12.8</td>
<td>21</td>
<td>22.3</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 5.3 shows that almost half of the teachers considered that the Geography passage was ‘very easy’ to read while less than a sixth of these teachers of Arabic considered the science texts (Biology and Physics) to be ‘very easy’ to read. On the other hand, the majority of expert respondents categorised the Physics passage as ‘hard’ or ‘very hard’
to read (51.1%). Participants appeared to consider that Year 10 students might have more trouble reading their science texts than their Geography or Arabic language subject texts.

Table 5.4 Perceived text difficulty

<table>
<thead>
<tr>
<th>Subject</th>
<th>Perception of difficulty</th>
<th>Ranked as most difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Biology</td>
<td>2.98</td>
<td>1.295</td>
</tr>
<tr>
<td>Geography</td>
<td>2.36</td>
<td>1.428</td>
</tr>
<tr>
<td>Arabic</td>
<td>2.60</td>
<td>1.454</td>
</tr>
<tr>
<td>Physics</td>
<td>3.28</td>
<td>1.387</td>
</tr>
</tbody>
</table>

Table 5.4 shows the mean scores for each of the samples (‘Perception of difficulty’) and the number of the Arabic experts who estimated each as being ‘very hard’ to read (‘Ranked as most difficult’). A one-way repeated measures analysis of variance (ANOVA) was used to compare the distributions of expert ratings of the four text samples. Boxplots and Shapiro-Wilk statistics indicated that the assumption of normality was supported: $F_{max}$ was 1.261, demonstrating homogeneity of variances; and Mauchly’s test indicated that the assumption of sphericity was not violated. The ANOVA results show that these experts recognised differences in the readability of these samples, $F (3, 279) = 13.847$, $p < 0.000$. The data in Table 5.4 are sufficiently robust to permit discussion.

The Physics sample had the highest mean difficulty (just over 2 on a 5 point range), followed by the Biology sample (just under 2). This is supported by the rank data derived from Table 5.4 that almost half of the participants identified either the Physics or Biology samples as ‘very hard’ to read.
As mentioned earlier, it might have been expected that background variables (Table 5.2), particularly experience in teaching Year 10 in Saudi schools, might have influenced the ratings of these language experts. However, SPSS cross tabulation of background variables against participant rating of the most difficult sample (Physics) did not show a single significant connection under the $\chi^2$ test ($p > 0.05$).

**5.9 Discussion**

The empirical base for this research rests on snowball sampling and so recruitment of a non-representative sample is the strongest threat to the validity of that approach. However, this study does not attempt to obtain a representative sample of expert opinion; rather it depends on recruitment of a sufficiently broad range of experts to provide a defensible estimate of relative text difficulty. Table 5.2 suggests that the participants provided by the sampling method represent a sufficiently appropriate and broad range of Arabic language experts: almost two-thirds of the participants were Year 10 teachers; nearly half had been teaching for over a decade and a similar number were teaching secondary school students; nearly a third were teaching intermediate students; and a quarter were teaching at the primary level. These people should be able to provide a defensible rating of these samples. The lack of significant difference according to background provides further confidence: they agree in their diversity.

Text sample length is a slightly more serious issue. The researchers made the decision to present the samples to the experts in the same form as they would appear to Year 10 readers, that is, as intact pages. This resulted in samples of differing numbers of words, but in this case authenticity would seem to outweigh consistency. There is a related issue with the Arabic readability formulas used as part of the background to this study, as the
Al-Heeti formula appears to take account of passage length, while the Al-Tamimi formula apparently does not. Readers will have noted that the two readability ‘measures’ differ on Table 5.1. This phenomenon is familiar from readability research in English (O’Toole & King 2010), where it has long been recognised that the vehicle for providing any numerical estimate of readability must be calibrated against the group for whom the graded text is intended. More importantly, Table 5.1 provides different rank estimations for the samples used in this study. Textbook readability in Arabic is not yet solid enough to permit firm action based on quantitative estimates of readability alone. Application of the Al-Heeti formula ranks Physics as easiest through Arabic and Geography to Biology as the most difficult sample to read, while application of the Al-Tamimi formula ranks the samples in reverse. The latter formula was developed to overcome perceived shortcomings in the former, so a difference between the results of the two is plausible. Also, the notes to Table 5.1 recognise that the estimates on the table were obtained by manual calculation on the basis of published work, so the present researchers may have misapplied either or both of the formulas. However, notwithstanding the differences, neither formula places any of the samples at above Year 8 level, leading to the assumption that all of them would rank as ‘easy’, if not ‘very easy’, for Year 10 students to read.

The results presented on Tables 5.3 and 5.4 suggest that the participating Saudi language experts do not agree. The formulas would provide over-optimistic estimates of text difficulty. Almost three quarters of the participants rated at least one of the samples as ‘very hard to read’ and almost a quarter rated the Physics sample as the ‘most difficult’ of all.
5.10 Conclusions

It appears clear that there are stylistic differences in the Arabic of Year 10 high school textbooks in Saudi Arabia. This study cannot comment on whether they are emerging at the moment or whether they are long-standing. However, the samples at the centre of this study are of discernibly different readability when assessed by the most readily available formulas (albeit in reverse order) and by application of a version of Judgement Analysis.

The results presented above allow the first research question to be answered in the affirmative: Year 10 Saudi text books are likely to differ in readability. It is therefore likely that some students are going to find them easier to use than others and, in a textbook-based jurisdiction, some differences in student performance are likely to result from differing degrees of access to the information contained in them.

It also appears clear that the science samples in general, and the Physics text in particular, may cause particular problems for students.

The second research question may also be answered in the affirmative. The results of this preliminary study suggest that secondary school science students, studying in Arabic-medium contexts, may have difficulties in understanding their school science books that are similar to those experienced by their English-medium counterparts. The substantial international work on English for Science and Technology at a variety of levels may be of use to Arabic medium teachers and researchers.
5.11 Implications

The formulas-based approach to estimates of text readability is not sensitive to the features of specific language styles, beyond the surface features of word and sentence length. The samples from science texts were considered to be the most difficult by almost half of the expert participants in this study. Comparison of the two samples in Appendix Q & T indicates differences between those two samples. The Physics sample contains mathematical expressions (as predicted by Lanka & Peks, 2013), and a high proportion of technical and scientific words (including units, concepts and numbers in English). All of these issues increase complexity of the reading task, which further problematises the acquisition of the required prior knowledge. This could hinder students as they engage with new concepts and laws in Physics and, in turn, is likely to prevent them from comprehending subsequent science texts (as suggested by Gallagher et al., 2012).

The causes of language complexities in science textbooks are worthy of further research. What are the features of ‘scientific Arabic’ that characterise Saudi Physics textbooks? The texts are apparently hard to read, harder than other school texts, but can a specialist style of Arabic be described? If it can be described, can the features that are causing particular problems for student be isolated and understood? Current research is underway to identify the pattern of features that may be producing the difficulties of readability evident in Year 10 Saudi Physics textbooks.
Chapter 6: A preliminary study of the technical use of Arabic in Saudi secondary physics classes

Originally published:

Abstract

English for specific purposes research reveals that learners at a variety of levels, experience difficulty reading science text, sufficient to impede their acquisition of science understanding. However, little research exists regarding subject-specific language styles and consequent reading difficulty in Arabic. Difficulties with specialised language may seriously impede the development of Physics understanding by Saudi students. Remedial attempts may remain ineffective unless informed by a better understanding of specific readability issues.

This quantitative study involved 80 female Year 10 students studying science in Abha in Saudi Arabia. A specialised cloze test, based on the mandatory physics textbook, was developed to identify language features of the passage that participating students found difficult. Findings reveal that:

(a) These Saudi students experienced greater difficulty in reading their Physics book (28% conceptually correct responses) than that suggested by earlier work with English speakers of similar age (62% conceptually correct responses); and,

(b) Saudi student difficulties with grammatical categories form a distinguishable pattern, but the pattern differs from that indicated by earlier work with English-speaking students.
6.1 Introduction

There have been recent educational developments within the Kingdom of Saudi Arabia. The establishment of the King Abdullah University of Science and Technology in 2009 indicated an increasing national commitment to science and technology (King Abdullah University of Science and Technology, n.d), and the recently released Saudi Vision 2030 incorporates the desire not only to increase investment in the digital economy, but for Saudi citizens to take an active leadership role and to contribute more directly to national development (Vision 2030, 2017). This vision will require more graduates with skills in science subjects to move into the Saudi and Middle Eastern economies (Cavacini, 2016). These technological developments fit well within the context of Saudi aspirations, as Islam strongly urges people to study and explore the universe within which we find ourselves. Muslim scholars have historically paid great attention to many different aspects of life such as medicine, astronomy, geography, mathematics, and the humanities. Seeking knowledge is obligatory in Islam for every Muslim, man and woman (Falagas, Zarkadoulia & Samonis 2006). However, Arabic is the language of the people in Arabian Peninsula and English is the language of international science and technology.

Content and Language Integrated Learning (CLIL) suggests that the entire science course should be taught in English, as occurs in parts of Europe (Lorenzo, Casal & Moore, 2009; Pérez-Cañado, 2012) and, more locally, in the United Arabic Emirates (Younes, 2016; Al-Bakri, 2013). However, recent work in Lebanon revealed a preference for communication in Arabic in local science classes (Salloum & Boujaoude, 2017). The Saudi context is slightly different as international expressions in English are being embedded within Arabic text.
Previous work with English suggests that communication in scientific contexts makes use of a specialist language style that can impede student understanding and subsequent success in science study (Philips & Norris, 2009). This paper documents a preliminary investigation into the existence of such a barrier within Arabic.

‘Literacy’ can have a range of meanings in different contexts. In its widest sense, it denotes access to specialised knowledge. The phrase “scientific literacy for all learners” expresses the major goal of science education, that is, to attain society’s aspirations and advance individual development within the context of science and technology (Bybee 1997, p. 69). This requires students to function in appropriate and purposeful ways within the variety of language forms that science learners confront: visual representation, mathematical symbolism, and experimental operations (Lemke, 1998). All of this happens within interacting pressures from encounters with instructional science and home languages (Yore & Treagust 2006). As Philips and Norris (2009) noted, the individual development to which Bybee (1997) refers depends on access to specialised knowledge. Expectations of such access may be misplaced.

So, in the present context, scientific literacy is taken to mean the reader’s ability to extract scientific understanding from text that embodies the intersection of specialist language and content. It is well established that in English, readers have difficulty with specialist language, particularly scientific language. Is there a pattern of difficulties for Arabic-speaking learners which is similar enough to that seen in English, to call for responses similar to those used in the field of English for specific purposes (ESP)?
6.2 Literature review

6.2.1 Science language

Arabic education is made complex by the diversity of vernaculars and their distance from Modern Standard Arabic. The use of specific styles of language in different school subjects may further complicate such a situation (Amin, 2009; Dagher & Boujaoude, 2011). Textbooks have long occupied a central place in school teaching in many contexts (Valverde, Bianchi & Wolfe, 2002) and learner access to the language within them is crucial to learning. The written language of the textbook in science subjects particularly, is fundamental. English-medium learners who are unable to read with understanding will have difficulty developing analytical understanding from their science textbooks and are consequently unlikely to develop the degree of scientific literacy suggested by Bybee (1997) and other science educators (Reeves, 2005). Many international jurisdictions require school students to gather information and data from reference books, journals and websites; follow instructions from manuals and interpret descriptive diagrams, tables and graphs. This has provoked recent interest in the ‘readability’ of Arabic texts (Arifin, Halim, Sham & Shukry, 2013).

Such ‘readability’ forms part of communication in science, which is the process that allows transfer of ideas and information between people (Zytun, 2008). This occurs through a range of media: orally; or through written schedules, diagrams, research reports; or through graphs, maps, and pictures (Mazen, 2007, 2008). Contemporary Saudi educational practice privileges written language and this makes reading scientific text a very important communicative skill for students, if they are to achieve commonly accepted science education goals (Khalil, 2012). Development of such skills should begin
in upper primary school levels and by the intermediate, school students should be able comprehend what they read; extract main ideas; interpret and present data; and make summaries of reading passages (Atiefa & Souror, 2011). All of this is problematic if students cannot read the text and the concept of general readability is an attempt to quantify the ease with which students may read different texts.

The use of mandated texts and the considerable uniformity of teaching practice within the centralised Saudi education system suggests that moving beyond such general readability may be useful. In the past, secondary school textbooks were entirely in Arabic and, for example, students could easily remember symbol names from the initial letter, for example velocity in Arabic is سارعٌة and the symbol is س which is the first letter but, in higher education, the science curriculum was presented in the English language. However, the most recent secondary texts for the science disciplines are translated into Arabic from English, except for numbers, symbols and unit names, presumably to ease the transition between secondary and tertiary education. The retention of such English expressions within the Arabic text is one of the novel features of the new textbooks. This inclusion of English in the symbols and the unit names might be difficult for secondary school students, as they process the measurement of movement to ‘9.8 m/s²’ from the Arabic expression م/ ث۲۸.۹

This is made more complex by the fact that the former English expression is read from left to right and the latter Arabic expression from right to left.

It has long been recognised that, within English, the written language of science is different from the more general language used in everyday life (Lindsay, 2011; Wellington & Osborne, 2001). It appears that successful English-medium science
students need to show an understanding of specific language of their textbooks; need to be able to use appropriate scientific and technical language; and need to use diagrams and tables to convey meaning (Hanrahan, 2009). Given the importance of centrally mandated science textbooks in the Saudi context, it may be of interest to discover whether similar expectations exist in Arabic-medium science classes. A specific form of Arabic may well be developing for use in scientific contexts, and this form may cause problems for learners. More information on the shape of such a specialised form of Arabic may inform the development of more effective responses to an increasingly recognised problem.

6.2.2 Cloze test

The modern cloze test was developed by Taylor (1953) as a tool to measure the readability of particular text. Construction of cloze tests (Gellert & Elbro, 2012) usually involves the deletion of a random word in the second sentence of a passage, then the deletion of every fifth (or seventh, ninth, eleventh or thirteenth) word thereafter until the desired number of words (usually 50) have been deleted. A particular group of readers then tries to replace the deleted words. The words, which readers suggest to fill the gaps left by the deletions that form a cloze test, can be scored strictly (where only exact replacement of the word deleted will be coded as correct) or conceptually (where synonymous ‘otherwise meaningful’ alternatives may be acceptable).

The group average of correct cloze responses is interpreted as an estimate of the access the specific group would have to the meaning of the particular text (Oller & Jonz, 1994). The individual deletions can also be categorised and average readers’ success in correctly replacing words of a particular category can be interpreted as reflecting more general
difficulty with the language feature represented by that category (O’Toole, Cheng & O’Toole, 2015).

The accessibility of a particular text depends on some factors arising from the text and others arising from the reader. Readability formulas in Arabic (such as those suggested by Al-Tamimi, Jaradat, Aljarrah & Ghanem, 2013) represent an attempt to quantify the difficulty that a particular text may pose for a generalised reader, in contrast to cloze tests which offer more opportunity to match particular texts against specific reader groups. This makes deletion-based cloze techniques potentially attractive as they avoid “artificial lines between language and content knowledge” (O’Sullivan, 2012, p. 83). The words deleted to form a cloze test may have grammatical or content functions. If learners cannot correctly fill the gaps while maintaining the meaning of the passage, then it can plausibly be inferred that they do not understand that passage. Contextual words form the most obvious problem within specialist text but failure to comprehend the grammatical framework within which they sit may make the passage equally incomprehensible. Problems in both areas at once are very likely to cause a learner to stop reading.

The cloze test has been employed to assess the level of learner readability within a variety of languages, such as English, Spanish, French and German. Most of the research on Arabic science textbooks attempts to measure the level of text readability, and analysis of exact replacement coding of cloze tests, suggests that students have palpable difficulty in reading their Arabic science texts (Al-Bardi, 2013; Al-Matrafi, 2010; Ktait, 2002). Research in Arabic language readability has focussed on automated and computerised measurement of readability (Forsyth, 2014).

Close analysis of student errors in replacing words into the gaps produced to form a cloze test can be used to identify specific language features causing problems for particular
groups of readers. In earlier work based on an English medium science text, over 2000 students completed a range of cloze-based test on English-language school science textbooks (O’Toole & O’Toole, 2004). This earlier study may allow preliminary comparison between English and Arabic patterns of difficulty, which may, in turn, indicate whether the wider English for specific-purposes literature provides any guidance for on-going work in Arabic. Consequently, the data for 654 female Year 10 students who specified English as their heritage language was extracted from this larger set of cloze results to produce a baseline for the present research; similar students studying physics in Arabic may have more, less or different degrees of difficulty with their science textbook. Cloze tasks from the earlier study indicated that, based on apparently age-appropriate science text in English, a sample of more than 600 adolescent students, yielded a mean result of 30.83/50 (standard deviation 11.56; 62% correct). This conceptually correct average cloze score suggests that a Year 10 female student sitting around the middle of this group would be unable to correctly replace over a third of the words deleted. Students who were less able readers of science texts would be able to successfully replace progressively fewer of the words deleted, indicating progressively greater difficulty in accessing the meaning of their science textbook.

This smaller set of data was further analysed to produce information regarding the difficulty these monolingual English-speaking students were having with features of their text. This more fine-grained analysis produced a pattern of difficulty with the features of the language of these science books that provides both evidence of some of the causes of student difficulty with the English of their science books and suggestions for remedial action. Broad similarity to this existing English data in the results of the present investigation would suggest that effective responses to these difficulties in English might
form a useful place to begin thinking about responses in Arabic-medium Saudi Physics classes.

6.3 Purpose of this study

Most existing research into the problems that can emerge where Arabic is the language of school instruction deal with the beginnings of literacy. There is research into; the features of Arabic language (Hammadi & Aziz, 2012; Neme & Laporte, 2013; Nwesri, Tahaghoghi & Scholer, 2005); diversity across different dialects (Bouhlila, 2011; Ibrahim & Aharon-Peretz, 2005); the role of vowels (Ibrahim, 2013; Seraye, 2016); the effect of morphology (Taha-Thomure, 2008); and, difficulties with spelling (Saiegh-Haddad, 2013). However, there is less research into the problems of older readers, for whom the written language of their science textbook is fundamental. This research aims to employ the cloze test procedure to identify the features of any such barrier to Saudi secondary school learner access to their physics textbook. Whereas exact replacement in the multiple-choice version of cloze forms the basis of recent attempts to estimate overall readability in Arabic (Arifin et al., 2013; Freahat, 2014; Ghani, Noh, & Yusoff, 2014), the current study uses conceptual coding of student answers to widen the evaluation of text comprehension. This study also looks more deeply into the language features to seek more specific patterns of language difficulty, following on from Mock’s (1974) point that a major limitation of cloze tests is their identification of readability levels without indicating the causes.

The present study is guided by the following specific research questions:

1. Does close linguistic analysis of Saudi student replacement of regular deletions from an authentic physics text reveal a pattern of language difficulty?
2. Does any emerging pattern match existing data on the problems faced by English-speaking students with the language of their science books?

6.4 Science education in Saudi schools

The Saudi Ministry of Education administers a centralised education system. Schools are gender segregated (Reda & Hamdan, 2015) and the 12 years of Saudi schooling are organised into three levels: six years in elementary, three years in intermediate and three years in secondary level. General Science is included in the elementary and intermediate levels and students study Chemistry, Biology and Physics separately at the secondary school level. Students in the first secondary year (usually 15-16 years of age) study each discipline for two periods per week. The most recent reform of secondary schooling provided Year 11 and 12 students with three options after they finish Year 10 (Ministry of Education, 2015). They may choose between Literary, Scientific, or Administrative streams. All students in the Science stream study Biology, Chemistry, Physics and Mathematics. Arabic is the medium of instruction (Ministry of Education, 2006).

Classes occur within the framework provided by centrally produced curricula. Teachers and students receive the mandatory textbooks without charge and teachers are obliged to cover all their mandated content (lessons, exercises and practical work) within specified periods.

6.5 Method

This quantitative study attempts to establish a baseline for further work on Saudi student difficulties with the Arabic of their physics books. This preliminary work rests on a close analysis of student errors from a cloze test based on a physics textbook that was mandated
locally (Rafee et al., 2014).

Although cloze techniques are potentially attractive, they have also long been the source of controversy (Brown, 2013; Sadeghi-Haddad, 2013; Spolsky, 2000; Stansfield, 2008). In the present case, the analysis of participant conceptual replacement of deleted items to reveal patterns of reader difficulty seems valid. Reader inability to suggest an entry that would maintain some meaning in the text implies some difficulty with the word deleted; and repeated inability to make such suggestions for deleted words of a similar class implies difficulty with that class of words within the specialist style.

6.5.1 Sample

This preliminary investigation was carried out in three government schools for girls in Abha, a city in the south of Saudi Arabia. Ethically defensible research methodology should take into account the culture of the fieldwork location (Al-Rashidi & Phan, 2015; Shaw, 1994). Education in Saudi Arabia is gender-segregated, and the primary author is female, so this study was carried out in girls’ schools. Eighty (80) Year 10 students, between 15 and 16 years old with Arabic as their mother tongue, completed the investigation instrument in Arabic.

Abha is a moderately-sized regional Saudi city with a developed educational system. The results obtained from schools there could be expected to be typical of such contexts within the Kingdom and the fact that the three schools are from the north, south and central parts of Abha should make them typical of any city. Year 10 was chosen because it is the first year of the more specialised secondary school years within Saudi Arabia. Students begin their study of the separate science disciplines at that time.
6.5.2 Instrument

A cloze test was based on the local physics text book (Rafee et al., 2014, pp. 77-79). This text was mandatory at the time of this study. Any learner difficulties consequent on its language could not be ameliorated by teacher choice of another resource. Teacher modifications for board work maintain the textbook language, as does the centralised examination system. The base passage is attached to this paper, both in the Arabic original (Appendix U) and loose English translation (Appendix W). The base text was produced by forming a coherent passage from text across the three pages specified in the reference above. The test instrument itself forms Appendix V.

The passage on which the cloze test was based dealt with gravity and Newton’s laws. The content had been covered in class by the participating students before they attempted the test. Student familiarity with this material from their mandatory physics textbook supports the validity of instrument developed from it. Every fifth word was replaced with a numbered gap and students were asked to enter the Arabic word that they thought most clearly maintained the meaning of the passage. The test as whole returned a reliability of 0.970 (Cronbach’s alpha) and the subtest reliabilities were: noun (0.877), pronoun (0.696), verb (0.781), adverb (0.653), conjunction (0.547), preposition (0.513) and technicality (0.892). The instrument as a whole, and these subtests all appear sufficiently valid and reliable to permit discussion.

6.5.3 Procedure

Previous contact had secured meetings between the first author and school authorities, at which she presented the Ministry permit and conducted a short meeting with teachers. This meeting described the procedure, and allowed arrangements for meetings with the
students to be made, after return of consent forms from both schools and students. The first author then introduced herself to participating students at these subsequent meetings and gave them some notes on the research and its importance in discovering aspects of language reading difficulty in the physics textbook. She explained (in Arabic) how to answer the cloze test saying “please read the passage and try to fill the missing gaps word” and stressed that “This is not a test to be given marks, but please try to be as honest and reliable as you possibly can”. Saudi schools use 45-minute class periods and so the students were given approximately this time to complete the investigation instrument.

6.5.4 Coding

The student entries were coded as exactly correct, conceptually correct or clearly wrong. The conceptual category was broad: any entry that maintained meaning was coded as conceptually correct. Analogous examples from English would be ‘movement’ for ‘motion’ and ‘form’ for ‘shape’. Deletions for which no entry was made after the final attempt were coded as ‘defeat’ and as ‘error’ before it, to distinguish between non-attempt and genuine inability. This coding produced the raw data for this investigation; which was entered into an Excel spreadsheet that was then uploaded into IBM SPSS Statistics 19.

The deletions were then analysed and patterns of student difficulty suggested by patterns of entry error. This analysis produced Table 1, with the following columns:

1. Words with affixes treated as a separate word, for example: (فإن) (so) the original word is إن (so that) and the first letter ف (fa) read from right to left is an affix. Affixes were separated because they potentially change substantial meaning and their separation follows precedents within the literature (Hmeidi et al., 2010). The
example below was the first missing word in the passage and happens to be a word without any affixes.

2. Translation of the word into English.

3. Part of speech (noun, adjectives, verb, adverb, pronoun, conjunction, preposition).

4. Transliteration.

5. Words classified as ‘technical’ are those which are used only within science. “Semi-technical” words are used in ordinary language but have a special meaning in science. The dictionary classifications and technicality codings rest on separate counts, so that there can be technical nouns and semi-technical adjectives (see Chapter 4).

6. Alternate meanings.

Table 6.1: Classification example for the first deleted word

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>عام</td>
<td>year</td>
<td>noun</td>
<td>aam</td>
<td>semi-</td>
<td>years, general technical</td>
</tr>
</tbody>
</table>

Cloze items were categorised by the Arabic language feature that they represented.

SPSS syntax routines were written to:

1. Define the conceptual total for each participating student;

2. Establish language feature sub-tests that would expose student difficulty with the cloze items grouped as representing various language features;

3. Generate mean error scores from the sub-tests for each language feature.

Data was extracted from the SPSS runs to provide the Arabic components of (see Figure 6.1 following) and the more detailed table that forms Appendix 4. The international data
used for pattern comparison purposes was drawn from extraction of data from the earlier study that uncovered the features of the language of science which caused problems for different groups of secondary students studying science in English.

Comparison of the two sets of data described below is indicative, rather than definitive. The student groups are approximately the same age and are at similar points in their differing education systems. The language features reported for English are chosen because they match those emerging from separate analysis of Arabic. Although the students did not complete the same cloze tests and were operating in completely different languages, indicative comparison of the shape of their difficulties allows suggestion of an answer to the second research question.

6.6 Results

The mean conceptual replacement score of the 80 participating physics students was 14.03/50 (standard deviation 10.044). Only 28% of deletions were filled with conceptually correct entries. It is likely that these results underestimate the level of difficulty posed by the text in question. They rest on mean scores: half of the class had greater difficulty than indicated and the mean is itself skewed by the use of the conceptual coding necessitated by the more detailed analysis that follows (O’Toole & King, 2011). These results provide quantitative support for expressions of reading difficulty that emerged from informal conversations between researcher and participating students. These students were unable to suggest conceptually correct entries for almost three quarters of the gaps formed by regular deletion and so they might indeed have difficulty understanding the book from which the passage was extracted. Such support for the
existence of a specialist language barrier in Arabic is interesting, but the nature and composition of that barrier is potentially of even greater interest.

Analysis of the language feature sub-tests gave some indication of the probable linguistic form of this barrier, again compared with earlier data for scientific English in secondary schools (see Figure 6.1 and Appendix X). The earlier English data is presented purely for illustrative purposes. The students were also completing Year 10 but the cloze tests were completely different.

It appears that these Saudi students are generally having more trouble with the Arabic of this physics text than the earlier students did with the English of their science books. This suggests that the barrier for students learning Physics in Arabic may be similar to, but possibly stronger than, that already documented for English. Figure 6.1 allows comparison of the form of barrier that may be provided by describable features Arabic of the school Physics textbook. If the barrier revealed by close analysis of student errors compares with that earlier revealed for English science text, then the greater volume of research available on English for specific purposes may provide some guidance for deeper and more thorough research on Arabic for specific purposes. This would extend the emerging work on readability in Arabic that was described earlier in this paper.

The relative size of the shapes in Figure 6.1 suggests that these Saudi Physics students are experiencing greater levels of overall difficulty than did their English-speaking counterparts. The barrier posed by the specific English that characterises science at both secondary and tertiary levels is fairly well established. Figure 6.1 and Appendix X indicate that there may well also be such a barrier in Arabic. Both Arabic and English readers have predictable difficulty with the technical words within their respective texts.
The data from the present study indicates that this happened even though the Saudi classes had previously studied the pages on which the cloze test was based. Failure to correctly interpret the function of deleted grammatical words may be more surprising and the two shapes on Figure 6.1 suggest that differing levels of difficulty with grammatical features may be characteristic of the two barriers. However, there is enough similarity between the two sets of data for the earlier work in English to provide some guidance for continuing work in Arabic.

![Figure 6.1: Levels of student difficulty with features of specialist language (mean percentage of deletions representing specified feature for which group was unable to suggest conceptually correct entry)](image)

6.7 Discussion

Teacher assumption of student understanding of features that do not seem particularly technical has been noticed in English-speaking technical contexts (Mudraya, 2006) and something similar may well be happening in these Saudi Physics classrooms, where such
lack of understanding probably compounds existing problems.

Current research into language difficulties in Arabic seems to focus on broader issues of readability as mentioned earlier. The students in this study seemed to be also having difficulty with the more ‘grammatical’ features of this school physics text in Arabic. Figure 1 indicates that the students got almost half of the deleted pronouns wrong and were unable to provide conceptually correct replacements for more than half of the adverbs, verbs, adjectives and conjunctions. These difficulties were identified through a more precise analysis of cloze results and they go beyond broad concerns with readability. The problems with pronouns deserve further investigation as they suggest student difficulties with text cohesion.

Teacher classroom roles greatly impact student performance. The Saudi teaching style has been traditionally teacher-centred but the new reforms call for a shift from teacher-to student-centred approaches, especially in science. Teacher perceptions of the new science textbook that embodies this approach will be discussed in a future publication.

English is currently the dominant international language for science, and science has been identified as the field of knowledge most responsible for the rapid global spread of the language (Ammon, 2001). Most members of the natural sciences academic community read English and the majority of books and articles are published in that language (Swaan, 2004).

However, controversy remains regarding the use of English, as opposed to students’ mother tongue, in secondary science education. Some educators recognise English as the gateway to innovations and new technology (Amin, 2009) while others clearly prefer use of the mother tongue (Salloum & Boujaoude, 2017) and such use of Arabic is made more
complicated by linguistic diversity among spoken forms and the Modern Standard Arabic used in textbooks (Dagher & Boujaoude, 2009).

6.8 Conclusions and implications

This preliminary study indicates that Saudi secondary school students studying physics may have difficulty with the Arabic text of their schoolbooks similar to the difficulty that English-speaking students have with the language of their school science books.

Whilst the actual patterns of difficulty differed in this study, the phenomenon seems clear enough to suggest that existing work on English for specific purposes may suggest possible paths for research into problems in Saudi classrooms. Content and Language Integrated Learning (CLIL) may also provide useful insights. This may also be of wider interest in the Arabic-speaking world.

The degree of difficulty with this mandatory textbook suggests that these Saudi students may face barriers in accessing the information contained in it. Student inadequacies are often suggested as the reason for such access difficulties, particularly in the case of female physics learners. However, these results suggest that at least some of the difficulty lies in text accessibility rather than learner competence. Attempts to increase student performance by focusing on motivation, relevance, class size or grouping, or other worthy educational innovations are likely to fail if they ignore the impact of communication difficulties such as those indicated in this paper.

These results support the relevance of approaches from English for specific purposes and CLIL to difficulties emerging in Saudi physics classes. For example, it may prove useful for physics teachers to be more explicit about the language expectations implicit in the textbook they are asking their students to read, and also more explicit about their own
expectations regarding what they expect their students to write. The results of the present study indicate that such explicit language teaching should go beyond the more obvious issues of technical language and reach into the grammar that this study has suggested is characteristic of this mandatory Saudi physics text. Direct treatment of technical vocabulary remains necessary but this study suggests that it will not be sufficient.

However, there are a number of limitations to this preliminary study. The widely recognised divergence between standard Arabic and regional and colloquial variants may explain at least some of the difficulties exposed here. These students may have the same difficulty with anything that they try to read. Students from these three schools may not be representative of female Saudi physics students. The base passage for this test instrument was compiled from several pages of the then-mandated textbook. This may not be fully typical of the reading tasks expected of Saudi physics students. Current changes in Saudi science texts may increase or reduce the difficulties experienced by contemporary secondary Physics students. All of these topics would provide fruitful directions for further research.

However, this preliminary investigation inspires sufficient confidence to suggest that further work on differences between the Arabic of general reading matter and that characteristic of secondary physics textbooks could be fruitful. The impact of the inclusion of technical terms in English on student understanding might be of particular interest. Widening the participant sample beyond a single city and involving a greater number of students would challenge the representativeness of these preliminary results. Use of the most recent textbook, intact pages of which include bilingual elements, diagrams and other discourse features of Saudi science text, would increase the representativeness of the text sample.
Notwithstanding such possibilities for further work, this study clearly indicates the existence of a pattern of reader difficulty that is likely to impede learner access to Saudi secondary Physics in Arabic.

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Chapter 7: Reading Difficulty and Language Features in an Arabic Physics Text

Originally published:

Abstract
Reading research in K-12 English-speaking contexts reveals that inferential and expository texts cause substantial difficulty for students but less such research exists regarding other languages. It was the purpose of this quantitative cloze-based study to expose any relationship between student difficulty and particular features of Arabic used in a mandatory Saudi Year 10 Physics textbook. Findings reveal that:

(a) These 360 female student participants appear to have significant difficulty understanding their textbook;

(b) Nouns seem to cause the greatest difficulty, followed by technical and semi-technical words, adjectives and grammatical particles; and,

(c) Prior knowledge did not appear to reduce reading difficulties.

This textbook may present difficulties for such students that go beyond the obvious issues of technicality in Physics text. This is significant because it suggests that the broader language difficulties that seem to characterise science text in English may also be emerging in specialist Arabic.

Keywords: Arabic, Physics, Language, Reading, Cloze
7.1 Introduction

Reading is one of the most complicated skills required of students, whichever language may be the vehicle for learning. Reading forms a particularly important part of learning when students move from elementary to high school and then on to tertiary education, as students move from ‘learning to read’ to ‘reading to learn’ (Herman, Perkins, Hansen, Gomez, & Gomez, 2010). Maturing students can find explanatory and expository texts more difficult to understand than the narrative texts that may be more familiar to them. Answering questions based on inferential and expository texts can consequently cause palpable difficulty for many high school readers (Britt, Richter & Rouai, 2014; Roberts, Takahashi, Hye-Jin, & Stodden, 2012).

Individual aspects such as attitude and the ability to integrate, evaluate and manage information seem to have particular influence when readers approach a science text (Morrow, Gambrell, & Pressley, 2008), which requires a foundation in technical scientific domain knowledge (Mikk & Kukemelk, 2010). It is crucial that science learners know how to read and write appropriately, if they are to respond effectively to learning challenges. Scientific literacy is an international issue (Bybee 1995, Murcia 2009) and, as Lemke (2004, p. 38) recognises, it is “not just the knowledge of scientific concepts and facts; it is the ability to make meaning conjointly with verbal concepts, mathematical relationships, visual representations, and manual technical operations”. Reading and writing complement each other in the development of science literacy (Rosenthal 1996). Learners attain comprehensive understanding through effective reading of a text and this subsequently enables them to write clearly on the text content, ultimately enabling them to express and build on what they have learned about science.
Student difficulty in comprehending what they read in science textbooks has emerged as a well-documented problem for researchers to address. Such difficulty does not merely arise from different levels of student ability in understanding the text but it also emerges from features of the text itself. “Text is much more than words, sentences and paragraphs but those things are the foundation for complex meaning built by purposeful readers” (O’Toole & King, 2010, p. 182). Purposeful specialist writers produce text that outsiders may not find particularly clear (Norris & Phillips, 2003). This has been a source of concern for a very long time. It has spawned the entire field of English for Specific Purposes, as the initial focus on English for Science and Technology widened to include other fields (Swales, 1985). The language of school science books has caused concern for even longer, with early readability formula (Lively & Pressey, 1923) being a response to the problems that their science books were causing for English-speaking students (Chall, 1988). The intersection of science and language has been the subject of a number of reviews (Hand, Yore, Jagger, & Prain, 2010; O’Toole, 1996; Rollnick, 2000) and ‘communication’ is becoming an increasingly common topic for research in science education.

The latest results in the TIMSS international science assessment for 2015 show a low performance for Saudi students in Year 8 compared to other countries. Saudi Arabia scored 396 from 500 points, which was lower than the results obtained in 2011 (Martin, Mullis, Foy, & Hooper, 2016). Student comprehension of science textbooks has become a key issue in science education in Saudi Arabia’s single-sex education system. The Ministry of Education provides free textbooks that define the course of study for both teachers and students. A new science curriculum was developed in 2008 through collaboration with Obeikan Research Development Company (Obeikan Education,
2013), which made an agreement with the American publishing company McGraw-Hill to translate Maths and Science textbooks for Grades K-12 (Al-Ghamdi & Al-Salouli, 2012; McGraw-Hill, n.d.) into Modern Standard Arabic, with slight adaptations to Saudi educational and cultural requirements (Al-Shamrani, 2012). The adoption of the McGraw-Hill series was intended to help Saudi teachers to be trained in student-centered teaching methods (Boujaoude & Gholam, 2014) that encouraged their students in scientific investigations using inquiry-based learning approaches (Al-Dahmash, Mansour, Al-Shamrani, & Al-Mohi, 2016).

Most of the relevant research on reading difficulties in science learning arises from English-speaking contexts but similar problems may occur in other languages. Recent work suggests the existence of distinct styles of English within specialist areas (Halliday, 1993; O’Toole, Cheng & O’Toole, 2015; Phillips & Norris, 2009). Gaining control of its specialist language and style may be the greatest obstacle to learning science in English (Wellington & Osborne, 2001) and to demonstrating such learning (Gee, 2003). Many science teachers underestimate the difficulty of the English texts that they expect their classes to read (Herman & Wardrip, 2012). One of the important features of science in English is the richness of the words and terms it uses, and many teachers consequently moderate their language in recognition that students have different abilities in understanding complex language and use a ‘medium’ level of language while they are teaching science. This level may not prepare students to read their textbooks independently.

The possibility of emerging specialist styles in Arabic, and potential student difficulty with them, prompts the present research. It seems clear that the specialist style of English used in school science books is a barrier for many students. The scientific style of English
has particular features and these form a pattern of difficulty for students that may partly arise from parental education, prior knowledge and language variations. The emergence of such a specialist style in Arabic may contribute to the poor performance of Saudi students on international tests.

The existence of any such specialist style could further complicate the already complex situation in Saudi classrooms where the local standard (MSA: Modern Standard Arabic) is only one of a variety of spoken forms of the language (Saiegh-Haddad & Schiff 2016). The content-rich nature of the scientific style makes students’ prior knowledge potentially important because familiarity should make text more accessible. The frequent abstraction that characterises the style makes parental education potentially important because familial discussion of abstract ideas could also make abstract text more accessible to students.

Consequently, the specific research questions that guide this work are:

1. Do some Saudi students have trouble in reading a mandatory science textbook?
2. Do the features of any apparent specialist style in Arabic prompt a noticeable pattern of difficulty for female Physics students who attempt to read such text and, if so, what is that pattern?
3. How do prior knowledge, language variety and parental education influence student performance when reading?

This paper focuses on the Arabic language used in Year 10 Saudi Physics textbooks. Textbooks are important because they are centrally-mandated as the sole basis of class work for teachers and students in Saudi schools (Al-Shamrani, 2012) and teachers are required to cover all the content from them. This makes reading a very important part of
learning in such classrooms. If the students cannot understand what they read in their textbooks, they will have difficulty learning the science contained in those books (Fang, 2005).

The Arabic language is the local medium of instruction. Skilled readers, in an earlier study, suggested that a passage from a Physics text was more difficult to read than other texts prepared for similar young people in Saudi Arabia (Albadi, O’Toole & Harkins, 2016). The cloze test used in the present study was based on that textbook passage. This finding raised intriguing questions about possible patterns in the Arabic of this specialist text, and about whether they might pose differential levels of difficulty.

Two additional factors give this study potential significance beyond its actual location. Three hundred and fifty nine million people speak Arabic as a first language and 1.4 billion people use the classical form for religious purposes (Middle East Monitor, 2017). Arabic is the language of instruction for very many children and identification of possible barriers to learning is consequently of great interest. Furthermore, as has been noted above, there is much research into the emergence of specialist forms of English but less research into possible recurrence of the phenomenon within other languages. This makes the present study of both practical and theoretical importance.

7.2 The cloze technique as a window into specialist language

The use of deletion-based comprehension tests re-emerged at the middle of last century (Taylor, 1953). Such ‘cloze’ tests assume that readers are better able to replace the missing words as their reading skills improve (DuBay, 2004). Producing a cloze test usually requires deletion of one word in five randomly from a target text (Alderson, 1979;
Oller & Conrad, 1971), although other intervals are sometimes used (Gunning, 2002). Deletion usually continues until 50 gaps appear (Taylor, 1956). This is considered to yield an adequate sample, as students (or readers in general) reading the text replace the deleted words (Gunning, 2002). Such replacements represent a measure of language abilities and proficiency (Bachman, 1985). The test challenges the direct connection between reader and passage (Stevens, Stevens, & Stevens, 1992). This type of test may also to be of practical value in teaching reading (Brown, 1985; Gilliland, 1972).

The overall cloze score can give an indication of the readability level of the passage and classifying the deleted words from the passage can help to determine specific student difficulties (Bormuth, 1968). Reader replacement of deleted words can be scored by either accepting only exact replacements (strict coding), or accepting (replacements that differ but are still meaningful) (conceptual coding).

Researchers in several Arab countries have used cloze tests to analyse a variety of textbooks written in the Arabic language (Al-Badrany, 2014; Al-Matrafi, 2010; Ambosae’di & Al-Erimi, 2004; Bugahoos & Ismaeel, 2001; Ktait, 2002). A limited number of studies have also analysed Arabic comprehension in both native and second-language readers (Abanami, 1982; Al-Heeti, 1984; Ghani, Noh, & Yusoff, 2014; Sesi, 1982; Toiemah, 1978). For example, an investigation of comprehension by Spanish and Arabic speakers reading in their native language and English at the University of Illinois revealed that participating students were more able to suggest correct grammatical items than they were able to fill deletions representing lexical items (Gilbert, 1984).

Other studies have focussed on estimating the readability level of particular subject texts. The majority of these investigations showed that students were able to exactly replace
fewer than a third of the words deleted, generating scores that fell into what would be the ‘frustration’ reading band, if the passages had been in English (Abanami, 1982; K. Al-Harbi, 2014; Al-Matrafi, 2010; Ambosae’di & Al-Erimi, 2004; Ktait, 2002).

Most existing work has used multiple-choice cloze tests or exact coding of manual cloze. However, Arabic builds on expanding word roots and this increases the range of possible valid participant suggestions for depletion replacements. Consequently, conceptual coding of reader attempts to replace deleted Arabic words may be more appropriate than exact coding (Badi, 1982) and there are indications that answers scored conceptually yield a higher reliability coefficient than those scored exactly. Toiemah acknowledged that the results for both approaches are very high: his two sub-tests showed 0.927 and 0.924 for exact replacement, and 0.944 and 0.956 for conceptual replacement (1978, pp. 109-110).

7.3 Method

The present quantitative study asked a group of 360 participating Saudi female Year 10 students from six secondary schools in two cities (Abha and Jeddah) to complete a cloze test based on part of the mandatory Physics text.

As indicated above, researchers most often use overall cloze test results to determine the readability of a text for a particular group of readers by counting the number of gaps correctly filled and comparing the average total with criterion scores. The present study takes a different approach: individual items deleted in the cloze text were first analysed to determine their linguistic categories and, following Toiemah (1978) and Badi (1982), subsequent analysis rested on participant conceptual replacement of the deleted items, to reveal linguistic patterns of student difficulty in reading the particular passage.
7.3.1 Tools

The cloze test used in this study is based on a passage from the mandatory Physics textbook, dealing with Newton’s Laws (Rafee, Hadad, Sabag, & Alorani, 2014, p. 105: see Appendix Y). Appendices preserve both the Arabic original (Appendix Y) and an English translation (Appendix Z).

This particular cloze test seems to possess content validity, based as it is on content-appropriate authentic text. It has face validity, in that inability to provide a conceptually correct word to fill the gap left by regular deletion seems connected with student difficulty in reading such text. It has construct validity, in that the deletions can be categorised in ways that match the conventions of Arabic grammar. Finally, this instrument seems to possess criterion validity in that cloze tests in general produce readability scores that are similar to those generated by less authentic tests (Oller & Jonz, 1994).

The first page of the study instrument includes demographic details: age, nationality, place of birth, father’s education level and mother’s education level. The second page includes the Physics passage with the first sentence left intact to allow the reader to get a better understanding of the topic, followed by regular deletion of every fifth word from the following sentences, until 50 deletions was reached and then the final sentence was left intact. Every fifth word was replaced with a numbered gap and students were asked to enter the word that they thought most clearly maintained the meaning of the passage onto a separate answer sheet. Each period in the Saudi Arabian school day is 45 minutes and this was the time available for student completion of the cloze test (See Appendix Y).

This deletion process followed the cloze procedure in English, where every sequence of characters separated by white spaces was counted as a word. The words deleted were
classified by part of speech (following Lancioni & Bettini, 2011) and the degree of technicality (Appendix AA). The groups of deletions sharing a particular language feature form ‘sub-tests’ within the cloze test. When the number of items within the sub-test, and its reliability, are adequate, mean student scores on these features can indicate student difficulty with the feature in question.

Both the Arabic and English languages share the major traditional parts of speech (pronouns, verbs, nouns, adjectives, articles, conjunctions and adverbs). The established grammatical analysis of Arabic also recognises several language-specific grammatical particles, which mark an adverbial clause, prepositional phrase, subjective complement, or symbol. This study began with the complete set of language categories, although not all appeared among the final 50 cloze deletions.

Further analysis determined the degree of technicality of the deleted words as either technical (occurring only in science), semi-technical (occurring elsewhere but having a particular meaning in science), or non-technical (O’Toole & Laugesen 2011). Commentators as early as Brooks (1926) noted that “Each of the sciences has its special vocabulary by which are expressed the basic concepts of the science. Most of them are seldom, and many are never, met with in general reading, but they are the principal or key-words in reading the subject-matter of any science” (p. 219) amid more recent recognition of classifications of technicality (Menon and Mukundan 2010).

An example of technical vocabulary from the Physics textbook passage is ‘gravity’ (al-jāthibīyah). The understanding of much subject-related technical vocabulary is dependent on learning context (Nation, 2001). Semi-technical vocabulary items occur frequently across disciplines (Cowan, 1974). An example from this passage is ‘the earth’ (al-ardh),
which in Physics refers to the planet, and in horticulture it refers to the soil. Non-technical items are words widely found in everyday use, for example, ‘thing’ (šay’).

### 7.3.2 Procedure

The primary author carried out the fieldwork for this study, beginning each school visit with a personal introduction to the teachers and an explanation of the research, after which consent forms were distributed. The researcher, school administrator and Physics’ teachers organised a time for participants to complete the cloze instrument after return of the consent forms.

The researcher explained to each class that the study did not relate to the students’ academic reports nor an examination of their academic competence, rather, the study intended to measure difficulties in textbook language. One of the six participating classes had previously taken the lesson on Newton’s Laws.

### 7.4 Analysis

The purpose of this study was to examine the students’ language difficulties in reading the mandatory Physics textbook, as influenced by students’ prior knowledge, and parental education. All 360 cloze tests were marked by the researcher and the answers coded as conceptually correct were revised three times to classify the broadly conceptually correct answers as either conceptually and grammatically correct or conceptually correct but grammatically incorrect.

The study used the analytic software SPSS24 to calculate the reliability of the 50 item cloze test and of the various subtests that emerged from categorisation of the deleted words. If the results indicated sufficient reliability, calculation of descriptive statistics
allowed overall and then detailed comparisons. Analysis of variance techniques suggested differing impact on the student cloze scores of various background variables.

The analysis described below indicates that the overall cloze test was sufficiently reliable to permit discussion (Cronbach $\alpha > 0.8$, see Table 7.1) and the results of language feature sub-tests were only discussed if they reached a reliability greater than $\alpha = 0.5$ (Hinton, McMurray, and Brownlow, 2004: see Table 7.1). The instrument appears both valid and reliable for the purposes of this paper.

**Overall difficulty.** The mean score of these 360 participating students, considered as a single group, was 10.43 from a possible score of 50 ($M = 20.86\% \ SD = 10.80$) when the entries were scored exactly (exact replacement reliability: Cronbach’s alpha = 0.896). The mean score of broad Conceptual coding (conceptually correct regardless of grammar) revealed an average of 17 of the 50 gaps forming this cloze tests were filled with a conceptually correct entry ($M = 34.44\%, \ SD= 16.94$) (see Table 7.1). A number of previous and recent studies have recommended use of conceptual answers (Brown, 1980; O’Toole, Cheng & O’Toole, 2015).

More than half of the cloze replacements were incorrect (65.54% neither exactly nor broadly conceptually correct). Overall test reliability, considering this error total and as measured by Cronbach’s alpha, was adequate for the purpose of current study ($\alpha = 0.892$).

Use of the broad conceptual total (and associated error total) will allow comparison of participant responses to differing language features.
Table 7.1: Overall cloze test scores

<table>
<thead>
<tr>
<th>Category</th>
<th>No of items</th>
<th>Reliability (Cronbach α)</th>
<th>Mean</th>
<th>Std Dvn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conceptual total</strong></td>
<td>50</td>
<td>0.896</td>
<td>34.44%</td>
<td>16.94</td>
</tr>
<tr>
<td><strong>Conceptually correct</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Error total</strong></td>
<td>50</td>
<td>0.892</td>
<td>65.54%</td>
<td>16.94</td>
</tr>
<tr>
<td><strong>Clearly wrong</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exact total</strong></td>
<td>50</td>
<td>0.829</td>
<td>20.86</td>
<td>10.806</td>
</tr>
</tbody>
</table>

Specific difficulties. When coding for conceptual correctness, those entries that were both grammatically and conceptually correct were coded separately from those that were conceptually correct but grammatically incorrect. Coding replacements that were conceptually correct and grammatically correct yielded a mean of 30.98% (SD= 15.75), and replacements which were conceptually acceptable but grammatically incorrect yielded a much lower mean of 3.47% (SD=2.80). This suggests that deeper investigation of student difficulties with particular language features may be illuminative.

Only those linguistic features whose categories within the cloze test contained three or more items and whose language feature sub-tests achieved Cronbach’s α reliability of 0.5 or above will be discussed here. This reduces the number of categories but increases the confidence that can be placed in that discussion.

Table 7.2 indicates that well over half of the noun deletions were incorrectly replaced (error M = 74.63%, SD = 17.24), indicating that the nouns were the most difficult category of items for the respondents. The second most difficult category was prepositions: just under half of the preposition items were answered correctly (error M = 50.79%, SD = 28.62).
Table 7.2: Student difficulties with specific language features (see Appendix AD)

<table>
<thead>
<tr>
<th>Category</th>
<th>No of items</th>
<th>Reliability Cronbach α</th>
<th>Mean% Wrong</th>
<th>Std Dvn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun</td>
<td>13</td>
<td>0.682</td>
<td>74.63</td>
<td>17.25</td>
</tr>
<tr>
<td>Preposition</td>
<td>7</td>
<td>0.690</td>
<td>50.79</td>
<td>28.62</td>
</tr>
<tr>
<td>Technical</td>
<td>9</td>
<td>0.586</td>
<td>72.99</td>
<td>17.88</td>
</tr>
<tr>
<td>Semi-technical</td>
<td>11</td>
<td>0.582</td>
<td>68.03</td>
<td>16.85</td>
</tr>
<tr>
<td>Non-technical</td>
<td>30</td>
<td>0.855</td>
<td>62.41</td>
<td>19.84</td>
</tr>
</tbody>
</table>

**Technicality issues.** Sub-analysis of student attempts to replace deleted technical words resulted in a high mean error score ($M = 72.99\%, SD = 17.88$) indicating that students experience greater difficulty when reading technical words (see Table 7.2). The result for semi-technical deletion was better ($error M = 68.03\%, SD = 16.85$). Non-technical words had the lowest mean error score of ($M = 62.41\%, SD = 19.83$). It is notable that all three of these categories had a mean error score of over 50% incorrect responses.

**Background variables.** Analysis of demographic variables revealed statistically significant differences between mean student cloze test results coded as conceptually correct, with regard to parents’ education level, student age and student nationalities.

There were statistically significant differences between group conceptual means as indicated by one-way ANOVA ($F (9.350) = 3.310, p = 0.001$) and ($F (8.351) = 3.654, p = 0.000$) for fathers and mothers respectively. Daughters of better-educated parents appear to have had less difficulty reading this Physics text.

The students varied with regard to nationality and age. The majority of students were Saudi, with the rest coming from another 12 nations: six where Arabic is the mother tongue and six where it is not (see Appendix AB & AC). One-way ANOVA revealed
statistically significant differences between group conceptual means on student nationality \((F (12.347) = 32.189, p = 0.012)\) and on student age \((F (6.353) = 3.683, p = 0.001)\). It appears from these results that students from contexts where Arabic is the medium of instruction would be able to read this Physics text more easily.

Table 7.3 shows the mean percentage of student conceptual answers in each school. There was not a statistically significant difference in mean conceptual totals between schools, as determined by one-way ANOVA \((F (5.354) = 0.697, p = 0.573)\). This is interesting because it suggests that neither dialect difference nor student prior knowledge of the passage made a statistically significant difference to the result. The group of students from the school which had already completed the work on Gravity (Jeddah 3) had a mean score \((M = 37.02\%)\) similar to or lower than results for other groups which had not previously studied this passage (see bold text on Table 7.3). This suggests that prior knowledge did not make this passage easier for these students to comprehend. The difference in dialect between the two cities has not leveraged a statistically significant difference in outcome.

Table 7.3: Impact of prior knowledge: Students at Jeddah 3 had done work on gravity

<table>
<thead>
<tr>
<th>School number</th>
<th>Mean Conceptual Total (%)</th>
<th>N</th>
<th>Std Dvn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeddah 1</td>
<td>37.54</td>
<td>65</td>
<td>9.532</td>
</tr>
<tr>
<td>Jeddah 2</td>
<td>35.08</td>
<td>67</td>
<td>8.541</td>
</tr>
<tr>
<td><strong>Jeddah 3</strong></td>
<td><strong>37.02</strong></td>
<td><strong>59</strong></td>
<td><strong>8.351</strong></td>
</tr>
<tr>
<td>Abha 1</td>
<td>33.38</td>
<td>58</td>
<td>7.519</td>
</tr>
<tr>
<td>Abha 2</td>
<td>31.78</td>
<td>56</td>
<td>7.512</td>
</tr>
<tr>
<td>Abha 3</td>
<td>31.10</td>
<td>55</td>
<td>8.859</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34.44</strong></td>
<td><strong>360</strong></td>
<td><strong>8.472</strong></td>
</tr>
</tbody>
</table>
7.5 Discussion

The overall results indicate that these Year 10 students had difficulty in comprehending this passage from their mandatory Physics textbook, even though conceptually correct entries were accepted. The overall mean, when participating student entries were coded exactly (20.86%), is comparable to the findings of earlier studies, a large number of which revealed that the participating students’ reading ability fell into the frustration level (Al-Badrany, 2014; K. Al-Harbi, 2014; Al-Matrafi, 2010). The mandatory textbook appears too difficult for the participating students to read.

As mentioned above, Gilbert (1984) found that readers had more difficulty with lexical items than grammatical ones. The results of the present study suggest that this is also the case in comprehension of this Physics text: these students seem to be getting the grammar right, if they are able to make some sense of the passage.

The current study allows expansion of earlier general work on readability in Arabic to the identification of specific difficulties with the language features present in mandatory textbooks. A specialist pattern of Arabic language is discernible in this Physics passage (see Table 7.2). These results show that nouns are associated with greater participant difficulty, followed by prepositions. Difficulties with nouns in a science text are to be expected but participant difficulty with Arabic prepositions is more surprising, suggesting that student reading difficulties may extend beyond technical nouns.

Nouns in Arabic have an extensive range of morphological types that produce complicated lexical forms (Ryding, 2005) and a recent study has noted that they are fundamental to Arabic school textbooks (Belkhouche, Harmain, Al-Taha, Al-Najjar, & Tibi, 2010).
Prepositions usually precede nouns and commonly occur in text (Nwesri, Tahaghoghi & Scholer, 2005) which explains why difficulty with this feature may pose such a reading barrier for learners. Toiemah (1978) also found prepositions to be difficult for the participants in his study. The results in the present study suggest substantial difficulty, with error totals of 50.79% for prepositions and 71.25% for slightly less reliable prepositional phrases.

Technicality (along with heavily nominalised usage) is a widely recognised feature of scientific writing in English and the results of our study indicate that items categorised as technical seem to be another barrier to students’ reading of science subjects in Arabic. Brown and Concannon (2016) recently drew attention to the importance of students’ understanding of vocabulary and reading strategies in learning science but the heavy use of both specialist vocabulary (Osborne, 2014) and mathematical terms can produce fairly obvious problems for readers. The relatively high error score for ‘semi-technical’ items (68.03%) suggests items such as ‘g’ (as symbol for the English word ‘gravity’) are not the only words causing difficulty. Semi-technical words are often complex with meanings that are quite different from those used in normal contexts (Yushau & Bokhari, 2005). In a Physics context this situation suggests that students have difficulty when faced with polysemous words (e.g. ‘earth’) when using them in Physics classes, leaving students in doubt as to the appropriate use of such words (Ncube, 2015). The difficulties with non-technical items do not simply indicate a general literacy problem. If readers do not understand the content expressed through technical and semi-technical words, they will be not be able to accurately apply non-technical words, many of which serve to maintain cohesion between key elements of meaning in the text. The deficiency in students’ full understanding of science vocabulary, whether technical or semi-technical, indicates
inadequate language communication in the classroom. Effective communication is highlighted as the essential component of teaching and learning in recent STEM education studies (Chrzanowski, Cieszyńska, & Ostrowska, 2015; Ní Riordáin, Coben, & Miller-Reilly, 2015). The well-intended recent changes in the science curriculum in Saudi Arabia, including the introduction of more English terminology and numbers, might pose barriers to learning, unless the question of how more effectively to communicate and develop learners’ understanding are addressed.

Research findings indicate that parents’ level of education has a positive impact in children’s achievement (Eccles, 1993). Partitioning participating student results by parent education revealed significant impact in both fathers’ and mothers’ level of education on the cloze test result. Recent studies support strong connections between girls and their parents in Arab culture (Dwairy, Achoui, Abouserie, & Farah, 2006a). Moreover, Al-Yousef (2009) has suggested that fathers had considerable influence on their daughters’ educational path in the Saudi context. She ascribed this more to greater emotional intimacy between fathers and daughters, and fathers’ ability to inspire their daughters, than to fathers’ knowledge of higher educational alternatives or educational experiences. This study indicates that mothers’ level of education also has a positive impact on student results, supporting previous findings in the Saudi context (Al-Mutalq, 1981, cited in Dwairy et al., 2006b, Basit, 1997, El-Biza, 2010) and reinforcing the essential role that the family plays in student learning performance in Islamic culture (Al-Sheikh, Parameswaran, & Elhoweris, 2010, Basit, 1997).

A significant relationship also appears between a student’s nationality, and presumably their previous language of instruction, and their cloze test results. Participants for whom Arabic was the medium of instruction appeared to have less difficulty than those for
whom it was a second or third language. However, the pattern within each of these two groups was diverse. A single student from Turkestan outperformed all others, although she did not come from an Arabic-medium nation and the seven Jordanian students appeared to have less difficulty with this Physics passage than their Saudi classmates.

The significant impact of student age is also noteworthy. There seems to be something optimal about the 15 year olds in this sample. It is clear that the younger students achieved better results than their older classmates. In Saudi Arabia, the schooling system has three different levels. Elementary school students are usually from six to 12 years old. Thirteen to 15 year old students are usually in an intermediate school. High school students are usually from 16 to 18 years old (Ministry of Education, n.d.). Consequently, we would expect students in the participating group to be around 15 years of age. Older students in this sample may have left school for a period or repeated a previous year of their schooling. Either situation could contribute to lower reading competence and a consequent lower score on this cloze test.

The lack of significant difference between the reading performance of students with prior knowledge and those without it was unexpected, although there are some indications of similar occurrences in English (Burton 2014). It appears that having prior knowledge had no impact on the reading score for these students, suggesting that this school Physics textbook may be an obstacle to student learning notwithstanding some familiarity with the content. These results also suggest that different Saudi dialects of Arabic may be less influential than the literature suggests. The results of this study reflect the lack of impact of the relatively slight dialectical difference between Jeddah and Abha. However, greater dialectical distance may have a greater impact than these results indicate (See Table 7.3).
The results of this study suggest that:

1. Some Saudi students clearly have trouble in reading a mandatory science textbook.
2. There is a noticeable pattern of features in the apparent specialist style of Arabic appearing in the mandatory Physics text. This pattern provides measurable difficulty for female Physics students who attempt to read such text.
3. Prior knowledge and language variety do not appear to make a statistically significant difference to the (admittedly low) reading performance of these female Saudi Year 10 Physics students but parental education apparently influences student performance when reading.
4. Similar difficulties may well occur in other contexts where Arabic is the medium of instruction.
5. The emergence of special purposes styles in languages other than English may well warrant further research.

7.6 Conclusion and implications

The major aims of this investigation were to investigate the style of language used in one Saudi Physics textbook, written in Arabic, and the difficulties that style might cause for science learners. The analysis provides an indication of a noticeable pattern of difficulty with language features of Arabic instructional text. The relationship of these features to a specialised style in physics text requires further consideration.

Cloze test results revealed low performance of students in reading the given Physics passage. Parental level of education appears to have had some effect on the ease with which some participating students could read this textbook, as does national origin and
student age. However, all of these Year 10 students appear to be having trouble with this mandatory resource, with a mean total of exactly correct responses = 20%, and maximum of 50%. What is surprising is the lack of statistically significant difference between the mean scores of students with prior knowledge and those without it.

The present results are significant in that they shed light on the major factors hindering the readability of this textbook: technicality, nouns and prepositions, particularly when technical words appear in English. However, a broader view of these findings implies that this textbook may present difficulties for such students that go beyond the obvious issues of technicality in Physics text. This has some bearing on the current situation in Abu Dhabi, where the Education Council recently launched a new system that uses English as a medium of instruction in science classes. Work by Kadbey, Dickson, and McMinn (2015) reveals teacher preference for teaching science in the Arabic language or the presence of co-Arabic teachers in science classes to support students’ understanding.

Issues surrounding language of instruction require exercise of great care.

Several questions remain unanswered. Is a clear description of the precise characteristics of the language of this Saudi Year 10 Physics text feasible? If so, does that language constitute a specialist style distinguishable from that of other reading matter for the same audience?

Most of the research in this area has focused on the level of overall text readability, or on the difference between local dialects and standard Arabic, with a plethora of studies investigating the effect of vowels written in Arabic on reading in general (Abu-Hamour, Al-Hmouz & Kenana, 2013; Abu-Rabia, 1997; Mohamed, Elbert, & Landerl, 2011; Saady, Ibrahim, & Eviatar, 2015).
The conservative approach adopted to the language described in this study has limited meaningful discussion of a number of language features. Perhaps an additional cloze test, focussing on features excluded from the present discussion may yield fruitful results. Further investigation of the style of language in science textbooks, in particular, could provide a basis for development of more effective textbook resources that could be used more effectively. This research sampled only female Physics students, due to the gender separation in the Saudi education system; comparison across genders would obviously be desirable for further research.

There is abundant opportunity for supplemental investigation drawing on teachers’ experience of contemporary changes in Physics education, such as the recent work in Abu Dhabi. Current research is underway to investigate the perceptions of Physics teachers in these girls’ schools and their approaches in implementing the new curriculum.

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Dr. Mousa Alzahrani, Faculty of Arabic Language, Department of Rhetoric and Criticism, Umm Al-Qura University

Mr. Ahmed Habib, Arabic Language Teacher
Chapter 8: Recent reforms in Saudi secondary science education: Teacher and student perceptions of Grade 10 Physics

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Abstract

Recent research in science education for learners whose first language is Arabic suggests that learning in the mother tongue can reduce learner misconceptions, but there has been little research into the comprehensibility of science texts where Arabic is the language of instruction. This mixed methods study describes the perceptions of substantial changes in science education, including translation of American science textbooks into Arabic, expressed by six Grade 10 Physics teachers and 360 Grade 10 Physics learners in two cities in Saudi Arabia. Factor analysis allowed themes emerging from the teacher interviews to be compared with underlying constructs from student questionnaire responses. Results reveal teacher and student concerns about adequacy of resourcing for the newly mandated student-centred style of learning, and language difficulties affecting comprehensibility of the textbook to support student learning. These findings suggest that science education policy-makers should consider all components of constructive alignment if they wish to achieve the goals of science education reform that they set for themselves.

Keywords

Curriculum reform, Physics, Policy borrowing, Secondary school science, Textbook,
8.1 Introduction

Recent years have seen huge efforts to overhaul education systems in Arab countries. Comprehensive knowledge-based reform programs are expected to develop a skilled workforce to accomplish national social and economic goals (Maroun, Samman, Moujaes, & Abouchakra, 2008), particularly in Saudi Arabia (Ministry of Education, 2006). One of the goals of secondary level changes in the Saudi education system is to develop students’ scientific thinking and deepen their motivation to engage in experimental research and consequently to improve their performance (Al-Gamdi & Abdul-Gawed, 2010).

Textbooks are widely recognised as a major source for learners. Text is commonly used to convey scientific concepts, and the ability to comprehend textbooks can be crucial to learner understanding of school science (Norris & Phillips, 2003; Pearson, Moje, & Greenleaf, 2010). How teachers utilise such textbooks so that learners improve their scientific literacy is fundamental (Sørvik & Mork, 2015).

8.2 Background to Saudi science education

The Saudi education system is centralised and all the policy and decision-making is authorised by the Ministry of Education (MoE) which provides textbooks for free for both teachers and students (Al-Mazroa & Al-Shamrani, 2015; Al-Qarni, 2013). The school system is characterised by gender-segregation (Rugh, 2002).

The dominance of the rote memorisation style of teaching and learning has been identified as a fault in the Saudi education system. Consequently, ongoing reform has emphasised developing learner practical skills and implementing collaborative work (Courington &
In 2003 the MoE announced a *King Abdullah Bin Abdul-Aziz 10 Year Education Project Plan* to operate between 2004 and 2014 (Ministry of Education, 2004), conducted by Tatweer Company for Education Services (Tatweer, 2010). This is one of the companies that belongs to Tatweer Education Holding Company, owned fully by the Public Investment Fund of the Kingdom of Saudi Arabia, and concerned with the development of public education in its various aspects. This project consists of four components all of which aim to integrate the educational process. These programs focus on curriculum affairs, teachers, classrooms, and non-curricula aspects, by developing and training teachers, creating better curricula and educational environments and by focussing closely on learner skills outside the classroom (Tayan, 2017).

In focusing on developing curriculum at the secondary level, the MoE stated its intention as “Improving secondary Education and its branches, and providing students with the necessary skills” (Ministry of Education, 2004, p. 15). The changes in Saudi secondary schools are intended to overcome barriers whether in the area of school buildings, teacher qualifications or the rigidity of the curriculum and methods (Al-Sonbul, Al-Khateeb, Motwali, & Abdulgawad, 2008). The three grades of secondary schooling include discipline-based science courses: Physics, Chemistry, Biology and Earth Science (Al-Dahmash, Mansour, Al-Shamrani, & Al-Mohi, 2016). Upon completion of Grade 10, students are required to choose between scientific, art and administrative tracks.

### 8.2.1 Old and new science curricula

A new textbook-based science curriculum was produced in collaboration with Obeikan Research Development, a private company currently implementing the largest educational K-12 development and educational reform program executed by a private
sector organisation in the Arab World, to develop Islamic textbooks for Mathematics and Natural Sciences for Saudi Arabia, the Gulf States and Yemen (Obeikan Education, 2013). This company contracted with the American publishing company McGraw-Hill to provide a translation of mathematics and science textbooks for Grades K-12 (Al-Ghamdi & Al-Salouli, 2012; McGraw-Hill, (n.d)). These books were translated from the original language (English) and slightly adapted in line with the Saudi educational environment and Saudi culture (Al-Shamrani, 2012). As this work was commercially contracted, little detail has been made available about the processes and procedures used in the translation and adaptation. The Obeikan company website (in Arabic) states that their translators worked with educators to ensure the quality of the translation.

Saudi teacher dissatisfaction with the existing physics textbook and the low education level of their students had prompted this almost direct transfer of science curricula and materials, which represents the first stage in the cross-national policy borrowing process described by Phillips and Ochs (2004). The Department of Curriculum in the Ministry of Education appears to have moved quickly to stage II, with textbook choice and translation resembling a ‘quick fix’. This raises questions about the suitability of this text and the basis for its selection in relation to the curriculum, as well as whether the language in the translated Physics textbook is suitable to the Saudi context. Such translated books might be missing some essential concepts and the method presented to students to improve their critical thinking may be inappropriate for Saudi students (Cook & Robert, 2016). This paper will examine that question without proceeding to detailed treatment of further stages in the illuminative model provided by Phillips and Ochs.

Many teachers considered the previous science textbooks to be boring and monotonous, to lack information and to focus on mathematics exercises that did not encourage student
participation in experimental work. Rather, the pedagogy was teacher-centered and based on learner memorisation (Al-Tawil, 2013).

Student-centered learning forms the basis of the new textbook, which supposedly allows students to engage with subject material directly rather than just memorizing it superficially. The new Physics textbook and curriculum was first introduced for Grade 10 in 2010-11; some teacher participants in our study reported receiving training at the beginning of that year, while others reported no training. The first, trial edition and teachers’ guides were used in 2010-11, a revised edition was issued for 2012-13, and a final edition was issued in 2014 and is used up to the present date. The new science pedagogy reflected in the textbook is an application of the constructivist theory of knowledge and focused on problem solving and critical thinking (Al-Ghamdi & Al-Salouli, 2012; Al-Kahtani, 2015). However, there are doubts that this new reform could be fully successful, as the content and quality of the American textbook is based on a specific Western community, which might not match the needs of Saudi students (Boujaoude & Gholam, 2014). These commentators have suggested that development of a science curriculum should involve local science teachers to produce a science textbook in alignment with the local education system.

8.2.2 Roles of Saudi teachers and students

Teachers have always been one of the main pillars of student achievement (Al-Nahdi, 2014), as they impart information and knowledge in a professional way in the classroom, forming an essential part of student success or failure in the whole learning process (World Bank, 2008). The traditional Saudi teaching style is didactic: the teacher gives the lesson and writes the information on the white board and the students receive it and then
transfer this information to their notebook (Al-Haidari, 2006; Al-Kahtani, 2015). As a result the classroom environment lacks dialogue between teacher and student and there is little student engagement unless the teacher asks a direct question and a student raises a hand to answer (Hamdan, 2014). However, there has been increasing pressure for teachers to encourage their students in critical thinking and help them to improve problem-solving skills and creativity across their subjects (Baqutayan, 2011).

Many students have also complained that the traditional teaching method lacks excitement and is deficient in critical thinking (Al-Lamnakrah, 2013b). However, Saudi cultural values encourage young people to respect their parents, elders, people and teachers through dutifully listening and obeying (Al-Mutairi, 2007; Sonleitner & Khelifa, 2005) and this can cause students to feel uncomfortable in questioning or discussing anything with their teacher on an apparently equal basis (Al-Wadai, 2015). Students consider the teacher to be the only source of knowledge and tend to follow instructions and memorise any facts being provided without adding their own input.

Teachers need to be well prepared to be able to implement the aims of this new collaborative pedagogy to increase student participation in a meaningful way (Al-Mazroa & Al-Shamrani, 2015). Saudi external professional teacher training may not adequately prepare them to teach the new science curriculum although they have apparently found the new curriculum interesting and potentially stimulating for students (Al-Ghamdi & Al-Salouli, 2012). Such interest can help to explain the strength of subsequent teacher frustration with overcrowded class and inadequate resources (Qablan, Mansour, Alshamrani, Aldahmash, & Sabbah, 2015).
The literature also reveals language as another issue in this new reform. Although Arabic is the medium of instruction in all subject classes in Saudi school life, the new Physics textbook includes English numbers, physics symbols, units and terminology. Cook and Robert (2016) assert the importance of using the international English science language terminology to help Arabic-speaking scientists to communicate with other national communities. Learning science in the English language seems to be a gateway toward implementing science and technology for the Arab world since English is the language of science, research, computing and communication (Ammon, 2001) and, furthermore, several researchers have commented on the difficulties of reading science textbooks in Arabic (Al-Badrany, 2014; Al-Bardi, 2013). However, aside from the difficulty of including English language, comprehending the Arabic language itself is a problematic issue for students due to the linguistic differences among the spoken language and the written language in the school textbook. The significance of developing the teaching and learning of the English language in the Saudi context has to be reconsidered to keep up with new innovations being published in English language as it is a global language (Mitchell & Al-Furaih, 2016). An alternative view suggests that learning science in the native language reduces learner misconceptions (Bayloun, 2015). Cook and Robert (2016, p. 9) however, lament that “The best of the Arabic science textbooks still tend to be adapted from foreign materials and are poorly translated, missing fundamental concepts or are simply inadequate for student engagement and development of critical thinking skills.” It seems that, as Baqutayan (2011) suggested, curriculum, language and teaching method are all imperative if we wish to improve the next generations, understanding of science.
Recent research by R. Al-Ghamdi (2017) found that Saudi girls’ positive attitude toward learning science often declines after elementary school level, with increasing boredom, particularly in physics. A positive correlation was found between students’ interest in science and their understanding.

8.3 Research question

This study aims to identify:

What are the teachers’ and learners’ perceptions of the latest Saudi science reform with specific relation to physics, particularly in terms of the style of written language in the textbook and of the new teaching strategies that are required?

8.4 Methodology

The study relies on both qualitative and quantitative data. The qualitative data came from interviews with one Physics teacher from each participating school and the quantitative data came from a survey of the students (age 15-16) in these teachers’ Grade 10 physics classes. The teacher interview protocol, as presented in Appendix EE, included three topics (curriculum, external resources and language) with each topic containing two to four questions. Using open-ended questions in the semi-structured interview design allowed the researcher to engage the interviewee beyond the questions and follow emerging issues in their expression of response regarding this new reform. Most of the interview questions concerned the textbook and how teachers use it. Participating students completed a 48 item survey consisting of items grouped into five scales including student learning personality, attitude toward teachers, attitude toward the physics
curriculum, attitude toward school, and attitude toward learning in general. Both the interview questions and the survey items were developed through consultation with experienced teachers and science educators in Saudi Arabia and Australia, contributing to their content validity. Formal validation was not considered necessary for the purposes of this study.

This mixed methods paper focuses mainly on the qualitative data, with quantitative analysis of student survey results allowing some comparison between teacher and student perceptions. Themes from the interview data were identified separately by each of the three authors, to boost reliability of this part of the analysis. This, together with factor analysis from the survey data, enabled some triangulation across similar themes emerging from both categories of participants.

8.4.1 Sample

This paper examines teacher and student perceptions of instructional materials used in contemporary Saudi physics classes. The sample of teachers and students was purposeful in the sense that three ‘girls only’ secondary schools were chosen from each of the two Saudi cities (Jeddah and Abha). These cities were chosen because they are representative of two different regions of Saudi Arabia. Jeddah is a large coastal city and Abha is a regional city of moderate size. Table 1 sets out the number of participating teachers and students from each of these schools. Most teachers had responsibility for two physics classes, each of which included approximately 30 students.
Table 8.1: Participants

<table>
<thead>
<tr>
<th>Teacher</th>
<th>City</th>
<th>Teaching Experience</th>
<th>School</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 1</td>
<td>Jeddah</td>
<td>28 years</td>
<td>School 1</td>
<td>65</td>
</tr>
<tr>
<td>Teacher 2</td>
<td>Jeddah</td>
<td>25 years</td>
<td>School 2</td>
<td>67</td>
</tr>
<tr>
<td>Teacher 3</td>
<td>Jeddah</td>
<td>29 years</td>
<td>School 3</td>
<td>59</td>
</tr>
<tr>
<td>Teacher 4</td>
<td>Abha</td>
<td>23 years</td>
<td>School 4</td>
<td>58</td>
</tr>
<tr>
<td>Teacher 5</td>
<td>Abha</td>
<td>8 years</td>
<td>School 5</td>
<td>56</td>
</tr>
<tr>
<td>Teacher 6</td>
<td>Abha</td>
<td>14 years</td>
<td>School 6</td>
<td>55</td>
</tr>
</tbody>
</table>

The twelve physics classes provided six teacher interviews and 360 completed surveys from grade 10 physics classes taught by those teachers. Specific attention was paid to how teachers used the mandatory textbook and how they used and explained specialist physics terminology in their classes.

8.4.2 *Ethical Issues*

Local and international ethical standards guided the design and conduct of the investigation. Local cultural priorities led to the selection of a single gender sample. The schools were chosen because they are typical of girls’ schools in those cities. Consent forms were distributed to the principal and teachers to clarify the purpose and the process of data collection. After receiving the teachers’ agreement to participate in this study, the interviews were conducted and recorded with institutional and participant consent. The interviews took about 30 minutes of teacher time and the survey took students around 20 to 30 minutes to complete. Participant pseudonyms (Teacher 1, Teacher 2 and so on) were used throughout the study in order to protect their confidentiality.
8.4.3 Procedure

Semi-structured interviews allow the researcher more flexibility to extract information (Minichiello, Aroni, & Hays, 2008) and so this approach was used for the six Grade 10 physics teachers. Johnson (2002) asserted the advantage of using the semi-structured interview for the researcher in that they are enabled to seek deeper information in comparison to other methods such as survey and focus group methods. The interviews were conducted in Arabic and the researcher translated the transcripts into English. Translations were checked for accuracy by an Arabic-English bilingual colleague not engaged in this research project. The survey for students was presented in Arabic, and the completed surveys from consenting participants were collected before the teachers were interviewed.

8.5 Data analysis

The qualitative component of this research made use of thematic analysis, in which the categories emerged from the data. The categories or themes in this research were identified in three main categories followed by sub-categories. The main categories included: textbook content, challenges to understanding the textbook, and textbook resourcing and teacher preparation. The results of the student survey were manually coded and the resulting data were entered into SPSS for analysis. The 47 survey items were initially subjected to the SPSS ‘Factor’ procedure and then culled and sorted to reveal underlying factors that could be compared with qualitative information emerging from the teacher interviews. Reliability was assessed by using Cronbach’s alpha to assess internal consistency, with a result of 0.832 for the whole instrument.
8.6 Results from teacher interviews (qualitative)

In line with the study’s aim to identify teacher perceptions of the science education reform with specific relation to physics, the three relevant themes identified from the data related to the new textbook and curriculum content, challenges in understanding the textbook, and teacher resourcing and preparation.

**Theme 1 Textbook content**

The data from the interviews indicated that among the six teachers, the three from Jeddah city had negative comments about the new textbook.

Teacher 1 commented that: “The old one is better than the new one”, and “When I prepare for the lesson I think that the information in the old textbook was explained better. I wish that they would have kept it like it was, the students will understand it directly from their textbook when they read it but now no they can’t”. Regarding the new textbook she said that: “The new reform, it is student-centered; the students should depend on themselves. But we still have to help our students; some parts in some lessons need to be explained in detail”.

Regarding developing students’ scientific skills, Teacher 2 said: “In Grade 10 the curriculum was easy but the examples in the physics book are very hard, like elasticity, stress, iron, wire. All these topics are not appropriate for Grade 10”.

Teacher 3 also has positive comments about the old textbook: “It was very clear. We used to write a class summary during the class. We all know that physics is a difficult subject but still it was easy to extract the information”.

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The three Abha physics teachers had more positive attitudes towards the new textbook. Their common response regarding the old textbook was negative in relation to the content and the large amount of repeated, difficult and ambiguous material.

Teachers 4, 5 and 6 agreed that the old textbook was not clear enough for students to read. Teacher 4 stated: “It is better than the old one, which was honestly very vague. Students finished their school with zero information - they were just studying to pass exams”, and she twice stressed: “The new curriculum is amazing”. Teacher 5 explained: “The old textbook represented information in a hard way and it’s hard to extract it. However, the current one is easier and it has answers to exercises, and a mathematics guideline, which the old one did not have. The current one cumulatively represents information to match students’ level of ability up to three levels which means that if students are able to master the high level of scientific thinking they will have specific questions that draw this out so it really takes into account the individual level of ability”.

The six teachers had dissimilar attitudes towards the new textbook’s organisation into topics, lessons and general presentation. The Jeddah teachers, who were more experienced, had negative attitudes toward the new textbook. They all agreed that the old one was clear and the topics were suitable for Grade 10 students. Teacher 1 mentioned that the information in the old one was “Sufficient but in the new one I feel that the information is presented as main points: headlines”. She explained that the new textbook: “talks about a specific point which it hasn’t talked about before or which will be in the next grade, or in a chapter at the end. Most of the information is repeated in the next chapter and so on. The old one is well organised - if it talks about one topic, it explains it and covers all the information regarding this topic”. Teacher 2 argued that the topics given in Grade 10 are very hard for students at their age level: “Motion and laws were in
grade 11 of the old curriculum, but now they are in Grade 10 which is very hard for us as physics teachers to teach our students these concepts at this level. Light and sound are very wonderful topics to teach Grade 10 students”. Teacher 3 focused on how the chapters were connected to each other: “In the old one the chapters were well connected from the first chapter to the second chapter and so on. The new one is not connected which means the first chapter is different from the second chapter - there is no correlation between them. The old one was clear, connected, and the definitions that were presented in the textbook were underlined. But the new one is not clear”.

The teachers from the city of Abha however, were much more positive about the new textbook. In contrast to their colleagues from Jeddah, they found the new textbook to be well organised and interesting for the students. Teacher 4 commented: “The way it presents the information and concepts is very easy and everyone can easily reach the information. The old one was very vague. It was full of unnecessary information. The new one again is amazing in the way that it presents ideas”. Teachers 5 and 6 held the same response that the new textbook is “Well structured. It has a summary of each chapter and a terminology list at the end of each chapter. It also has a mathematics guideline and any formula that is needed can be found in this guideline. This makes the textbook a very comprehensive reference for students” (Teacher 5).

In relation to the amount of material needing to be covered within the lesson times allocated, teachers 1, 2, 3, 4, and 6 agreed that the number of physics periods (two lessons a week) was insufficient to fulfil the pedagogical aims. They argued that the inquiry-based learning, on which the new teaching reforms are based, needs more time to cover the content. Teacher 1 said: “Two periods and 45 minutes are not enough. Especially with
this new curriculum and pedagogy we need more than the two periods even if it is 45 minutes”.

Teacher 4 said: “Everything in this textbook is amazing but it needs more time. The time is not enough”. Teachers 1 and 6 emphasised the density of mathematics exercises consuming classroom time. Teacher 1 said: “I spend more time doing math because the textbooks include a lot of math exercises”, while Teacher 6 commented: “The class period lengths are not sufficient. They need more time because they have a lot of exercises and problem solving to do”. Teacher 5 however, found that the time was sufficient because she (like others, see Theme 3 below), did not follow the pedagogy that this new reform required. In her words: “Yes, physics periods are sufficient because I don’t do the active strategies in learning. If I do it I think I would need more periods”.

The three Jeddah teachers identified lack of student foundation in literacy and numeracy from previous grades as another challenge in the implementing of the new pedagogy. Teacher 1 stated: “Their foundation was wrong. Students are now suffering poor reading and writing unfortunately”. She further clarified the problem she faced with students’ poor foundation in mathematics saying that: “The problem is sometimes with mathematics. At this stage, they should have basic knowledge in math from their previous grades in this subject. When we try to write the answers to an equation, and ask students to change symbols to number values, they struggle. They cannot answer although this is one of the most important steps in answering the math problems. I face a huge problem with their lack of basic knowledge in math”. Teacher 3 also had similar struggles with her students in math. She says: “Unfortunately, some of our students in a secondary school are very weak with some of the basic things like addition, subtraction, divisions. They don’t know them properly”. Teacher 2 added that beside their poor foundation in
mathematics, students still rely on their teachers to highlight important points in the textbook: “The new generation just rely on memorizing everything, highlighting and underlining what their teachers say is important”.

**Theme 2 Challenges in understanding the textbook**

More experienced teachers (Jeddah teachers) all commented that the textbook’s use of English and written Arabic created language difficulties and were in agreement that the use of English language in the physics textbook was a source of confusion for them as they began to use it, despite their many years of teaching experience. As Teacher 1 remarked: “When I explain the lesson in Arabic and pronounce the numbers and units in Arabic but write them in English, it’s really annoying”. Also, “problems appear as a result of the translation. It might be I feel that there is something missing in the textbook and there is some information which is not existing, that there is something missing”. Teacher 2 expanded on these comments: “I faced problems in the first year when we wrote equations in that we used to write it from right to left but then to follow the English in the textbook, we had to change that from left to right”. She questioned why the textbook had to include the English language, when Arabic was their native language: “From my point of view why should we include English in our textbook? This is not our language”. Teachers 1, 3 and 5 gave weight to the point that their students were poor in the English language and that this new textbook hindered them from learning the units and samples effectively as they used to in the past to derive the symbols from the initial letter of the unit name which was in Arabic. Teacher 3 said: “It is difficult for them and their ability in the English language, in general, is very low” and “In the past it was easy for them to derive the symbol from the name (like Force, mass, accelerate) in Arabic”.

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The Abha teachers in general however, had no difficulties with the inclusion of the English language. Teacher 4 said that while she had had a little difficulty with English in the beginning, her students had not faced any real difficulties with it overall. Teachers 5 and 6 agreed with her.

Regarding specific difficulties for students that the textbook presented, Teacher 1 had a strong negative response toward the style of Arabic language in which it was written. She states: “Sometimes I find in some parts there is a problem in the writing. I sometimes can’t understand what is required - not clear. The information is clear in some chapters but often vague in others. Later I realised that the problems were in the way that the prepositions were used. For example, you can find lots of them on many lines at times yet sometimes lines are missing them as well. In addition, you can notice that there are many Arabic grammatical problems. Also there is an extra letter in a word or a missing letter from a word which requires you to read the sentence several times to understand it”. Teacher 2 asserted that her students always complained that they did not like this new textbook. She stressed the point that students find difficulties in reading and writing as well. She said: “Students are facing troubles. They find difficulties in reading and writing. Yesterday I marked their exams, and I noticed that they wrote the number 40 incorrectly as 04”. Teacher 3 had a similar view as she criticised the language in the textbook: “Students are suffering when reading it. They get lost - nothing is clear; neither definitions nor listings are clear”. She added: “Look the physics subject is hard. Students find it hard to extract the information so if the textbook presents the information in a smoothly and clearly with headlines and clear listings as the old textbook used to, then the students may understand the textbook easily, but now no, they get lost. It has to be revised again and again”. She continued: “Students are struggling with physics symbols
- for example; when I tell them \( \text{Force} = \text{mass} \times \text{acceleration} \) they got it OK but when I ask them to write the formula they cannot”. Teacher 5 focused on the new style of teaching and learning. She argued that students’ attitudes toward learning are still following the old style. They do not understand that this new pedagogy depends on self-learning as she said: “students’ attitudes toward learning and toward the subject until now - I’m still following the old style of teaching. There is no self-learning. The current curriculum is built on self-learning and students don’t accept this way of learning. They still rely on their teachers to summarise and explain so they like the way of repeating what the teacher said and memorising it”. All teachers agreed that this textbook was not easily readable - neither for students, nor for teachers, but the latter’s experience played a vital role in coping with this textbook. They found that if any student was absent that it was impossible for them to ‘catch up’ or understand the content of the missing lesson by reading through the textbook alone.

**Theme 3 Textbook resources and teacher preparation**

The interviewees agreed that there was a lack of training in teaching this new textbook. All teachers had their training for the implementation of this new textbook during the school term. They complained that the training should have been before the new school term started (during the last school days of the year before implementation). Teacher 1 said that this training caused classes to be missed but that the trainers themselves had not realised how long an effective introduction was going to take. The teachers claimed that they needed the trainers to provide an explanation of the changes and their application to regular lessons, along with presentation of actual experiments enacted in front of them, step-by-step, according to the new reforms.
Further obstacles in the initial implementation of the textbook, as Teacher 3 recalls, included an issue with omission of detail in Teacher's book, three years previously, causing teachers to struggle to find answers to mathematical exercises. The original teacher guideline to the textbook provided only final answers without showing any mathematical workings, until the modified version rectified this.

In regard to searching for resources, all teacher participants mentioned their previous reliance on external resources, although the teachers with more experience revealed that they no longer needed to refer to those external sources so frequently. Moreover, five teachers reported that laboratory equipment was not so readily available in most schools except for certain equipment needed for the new practical assessment requirements. Teacher 6 said that all tools were available in her school. Teacher 5 argued that the problem was not just with equipment needed for experiments, but that it also included challenging classroom environments, and the issue of ‘overcrowding of students’ in each class. She remarked that all of these remain barriers for her in being able to apply the new teaching pedagogy.

Regarding the teaching strategies that they used to deliver their lessons, each teacher had a different technique according to their experience and their response. Most of the teachers found that they are still using the old style of teaching, confirming that while changes were made within the new textbook, lack of change in the classroom environments, materials availability, class sizes or number of periods to support the new teaching pedagogy, made it difficult for her to apply the new strategies. As an example, the new reform required students to do a project, which would contribute 10 marks to their final score. Teacher 1 commented that it was wasting time. In her words: “In my response students are under too much pressure. They have a lot of homework; projects
for each subject; and they have 9 subjects or more; so it’s very hard for students to cope with all of these”. Teacher 1 confirmed that she did not use any of the new strategies but that she just employed the traditional teacher-centred strategies according to the old textbook, due to barriers such as those previously mentioned. She also commented that she didn’t need to do any summarizing or highlighting for any lesson from the old textbook as it was so clearly laid out, but that now she feels forced to do that work for students due to overly complex lessons that were hard for students to understand. Teachers 2 and 3 expressed similar views. Teacher 2 said, “I force myself to do things that I don’t like to do at all”. Teacher 3 commented: “Due to the difficulties in the book, we read with the students and ask them to highlight and underline. We particularly ask them to highlight definitions, and make some sub-headings as well”. On the contrary, Teacher 4 found it unnecessary to highlight with students because she found the textbook to be clear and amazing. Teacher 5 mentioned again regarding self-learning and the benefits of it provided that students understand the ideas behind this approach and apply them. She said that she always encourages group work and gives awards to students to encourage them: “We try to support students by giving them awards especially when they have group work”. Teacher 2 preferred to use a variety of video clips to demonstrate information in an engaging way for students as she found that the method of providing authentic representation was preferable to decontextualised learning, which often bores students. Teacher 6 focused on how she could encourage her students to be able to write their answers according to their understanding rather than just memorising. She said: “Write the answers to show me your understanding, not just to show me that you have memorised it”.

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Teachers with greater amounts of experience are able to adapt themselves to this reform, including the barriers that they faced in the beginning, by drawing on their skill and experience to assess the most effective strategies that students need in order that the teachers could successfully cover all the textbook content that they need to teach.

Teacher 2 (25 years’ experience) and Teacher 4 (23 years’ experience) both advised other teachers to be collaborative and constructive in their communication with each other, sharing their experiences in order to gain collective expertise. Teacher 2 focused on how teachers can prepare their lessons. She first advises that teachers divide any hard lessons into parts, (even math exercises), and to make sure that students fully understand current content material before she moves on to new parts of the lesson. She advises, “If the lesson is hard you have to divide the lesson into parts and try to make a revision after each point”. Teacher 3 (29 years’ experience) always depends on her experience when extracting information after reading it from the textbook. She also advises other teachers to search for and refer to external references like finding experiments and not just sticking with the textbook. She encourages teachers to borrow information from external sources: “You do not have to stick with the textbook experiments”. Teacher 4 finds that it is expedient for teachers to go to their students’ level and not feel they need to explain everything but to encourage students to think, discover and engage themselves with the lesson content on their own rather than just relying on memorising everything. She believes that using group work in her classroom is an effective strategy to activate student centred learning: “Using the group work strategy is very effective. The most important thing is to keep students participating in the lesson”.
8.7 Results from student survey (quantitative)

In order to identify Saudi Grade 10 learners’ perceptions of the science reform with specific relation to physics, the data from the student survey was subjected to initial factor analysis. The Kaiser-Meyer Olkin measure of sampling adequacy was low (KMO = 0.467) and Bartlett’s test of sphericity was significant ($\chi^2 = 2627.319, p = 0.000$) suggesting that the data from the 47 items was not suitable for Factor Analysis. Items which showed factor loadings of greater than 4.00 were then selected from the original data and reanalysis revealed that the 17 remaining factors explained 54.53% of the total variance, with ‘suitable’ sampling adequacy (KMO = 0.755) (Allen & Bennett, 2010, p. 204) This re-analysis reduced the 17 items to seven factors, each factor comprising between one and four items. The rotated component matrix allowed identification of the items that loaded high on each factor. Examination of the items loading highly suggested the following components of the student response data (see Table 8.2). A single question serves as surrogate for the other items loading onto the particular factor (Hair, Anderson, Tatham & Black, 1995). The item numbers of these surrogates appear in the second column in Table 8.2, in order of their sequence in the full questionnaire. The full set of items corresponding to each factor is in Appendix FF.
Table 8.2: Questionnaire items responding to each surrogate

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor surrogate item</th>
<th>Factor surrogate responded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive attitude to physics learning</td>
<td>Item 37</td>
<td>‘Love laboratory lessons’</td>
</tr>
<tr>
<td>Supportive school environment</td>
<td>Item 22</td>
<td>‘School good environment’</td>
</tr>
<tr>
<td>General literacy</td>
<td>Item 36</td>
<td>‘Read things not connected to school’</td>
</tr>
<tr>
<td>Physics readability</td>
<td>Item 20</td>
<td>‘Understand after reading textbook’</td>
</tr>
<tr>
<td>Positive attitude towards science</td>
<td>Item 21</td>
<td>‘Love science TV shows’</td>
</tr>
<tr>
<td>Help at home</td>
<td>Item 23</td>
<td>‘Sibling helps with homework’</td>
</tr>
<tr>
<td>Teacher uses Modern Standard Arabic</td>
<td>Item 7</td>
<td>‘MSA in class’</td>
</tr>
</tbody>
</table>

Table 8.3 (below) shows the percentage frequency of the student responses to the seven factors, represented by their surrogate items.
Table 8.3: Student responses to factor surrogates

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean²</th>
<th>Std. dev.%</th>
<th>Almost every day (6)</th>
<th>Often (5)</th>
<th>Sometimes (4)</th>
<th>Not very much (3)</th>
<th>Very rarely (2)</th>
<th>Never (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive attitude to physics learning</td>
<td>4.65</td>
<td>1.23</td>
<td>26.1(94)</td>
<td>35.8(129)</td>
<td>26.1(94)</td>
<td>5.3(19)</td>
<td>2.5 (9)</td>
<td>3.9 (14)</td>
</tr>
<tr>
<td>Supportive school environment</td>
<td>3.98</td>
<td>1.76</td>
<td>26.4 (95)</td>
<td>19.4(70)</td>
<td>15.6(56)</td>
<td>14.7(53)</td>
<td>12.5(45)</td>
<td>10.8(39)</td>
</tr>
<tr>
<td>General literacy</td>
<td>3.92</td>
<td>1.99</td>
<td>35.3(127)</td>
<td>13.6(49)</td>
<td>12.2(44)</td>
<td>6.7(24)</td>
<td>10.8(39)</td>
<td>21.4(77)</td>
</tr>
<tr>
<td>Physics readability</td>
<td>3.13</td>
<td>1.63</td>
<td>7.2(26)</td>
<td>16.4(59)</td>
<td>21.4(77)</td>
<td>18.1(56)</td>
<td>11.7(42)</td>
<td>24.7(89)</td>
</tr>
<tr>
<td>Positive attitude towards science</td>
<td>3.29</td>
<td>1.80</td>
<td>15.8(57)</td>
<td>14.2(51)</td>
<td>18.1(56)</td>
<td>12.8(46)</td>
<td>14.2(51)</td>
<td>24.7(89)</td>
</tr>
<tr>
<td>Help at home.</td>
<td>2.85</td>
<td>1.90</td>
<td>12.2(44)</td>
<td>14.2(51)</td>
<td>14.4(52)</td>
<td>7.5(27)</td>
<td>10.3(37)</td>
<td>40.0(144)</td>
</tr>
<tr>
<td>Teacher uses MSA</td>
<td>3.19</td>
<td>1.81</td>
<td>10.6(38)</td>
<td>20.9(75)</td>
<td>15.9(57)</td>
<td>13.6(49)</td>
<td>10.9(39)</td>
<td>25.3(91)</td>
</tr>
</tbody>
</table>

Notes:

* Likert scale: Agreement (scale was frequency for the other items).

¹ % (number)

² mean Likert ‘score’ from a six point scale
The table above shows the factors extracted from the student survey. This group of 360 students seemed to like learning physics and laboratory activities (Table 8.3 Item 37). This group of students seem more ambivalent about the school environment, reading books outside of their school context, the readability of their physics textbook and learning science in general. The family support factor was very low as relayed by the students’ responses in the survey. Almost half of these students reported that their physics teachers did not use Modern Standard Arabic inside the classroom (using local Arabic dialects instead).

8.8 Discussion

This discussion highlights the major themes that emerged from the teacher interviews, and triangulates these with themes that emerged from the student surveys. The responses under several factors from the student surveys connect with themes from the teacher interviews; no major discrepancies were found between teacher and student responses. Teachers were, understandably, more informative about the practicalities of instruction, while student responses indicated how these impacted on them.

Both teachers and students seemed concerned with the importance of using experiments to deliver knowledge, as the students responded strongly to two survey items (see Appendix AF) indicating their preference for using experiments. However, teachers remarked that the tools provided for in-class experiments were often limited to those that were required for students’ practical exams and complained about the lack of choice in the range of available laboratory tools.
However, the data generated from the interviews indicated contrary responses among teachers towards the change in textbook. Jeddah teachers (more experienced) expressed more negative attitudes toward this new textbook, that it was difficult for students and required extra help from their teachers. Abha teachers seemed to be find this new textbook more interesting. Among students, nearly 40% responded that the textbook’s design and colour made it easier to understand, while 43% of the student sample answered that they found that the textbook in general was not clear. Student responses thus echoed ambivalent teacher responses regarding the usefulness of the new textbook.

Although the less experienced teachers (Abha teachers) were happier with the curriculum reform, all of the participating teachers still followed the old traditional style of teaching, which is consistent with findings from other studies (Al-Dahmash and Al-Shamrani, 2012). Although the participants seemed initially excited about shifting their traditional method of teaching to the student-centred inquiry-based learning approach, lack of classroom equipment, laboratory instruments, class sizes and shorter class periods all contributed to teacher reversion to traditional teacher-centred methods. As there was little variation in class sizes, there was no opportunity to investigate whether smaller classes would have assisted student-centred teaching. Some teachers reported using group work or ICT if they were available and argued that the impediments described above acted against their desire to fulfil this new reform, as also found in other studies (Al-Ghamdi and Al-Salouli, 2012). Transforming teaching approaches requires time to enable teachers to use them effectively (Fogleman, McNeill, & Krajcik, 2011).

Students’ preference for learning through experiments, mentioned above, suggests a positive attitude to more student-centred learning in science. Students were ambivalent about whether their school was a good environment for studying, and a few felt that it was
like a second home. Relatively few students felt that their school supports independent, active learning through research or experiments outside the school. More than half the student participants, however, found the school laboratory technician to be helpful in their practical work.

Focussing more specifically on the textbook, the more experienced teachers emphasised problems with the written language presented in the textbook. These teachers raised the issue of language problems in the textbook material translated from foreign sources. They highlighted a loss of clarity of meaning after translation issuing from grammar irregularities, particularly the unclear use of prepositions, causing issues in how the sentences were presented in the passages. One of these teachers stated that they felt that there was something missing in the writing.

For learners, learning to understand the language of science is just as essential as the learning of science itself. This situation is further complicated in the Saudi context as all textbooks are written in Modern Standard Arabic (MSA), which is derived from Classical Arabic and differs vastly from the spoken Arabic language in its numerous and diverse local forms (Al-Mamari, 2011; Wahba, 2006). The use of scientific English terminology and language in the recent textbook compounded these difficulties. These teachers struggled in the beginning of this new reform as they complained of the lack of preparation and adjustment of practice to it. Using English symbols and terms in the physics units, symbols and numbers can cause confusion for the learner. In the past, learners used to associate the units and symbols with their initial letters because they were written in the Arabic language, but their weakness in English might cause an obstacle for the learning of physics. A majority of student responses confirmed that they found the use of English in the physics book a source of difficulty. Their responses confirmed that
not all teachers used the Modern Standard Arabic of the textbook in their teaching, using local dialects instead, and not many teachers translated the English terms into Arabic.

These points of view have not been deeply investigated in previous literature with regard to the new Saudi education reforms. Our findings support the suggestion that the importation of a foreign, albeit ‘global’ or ‘common’, curriculum reform into a different cultural and educational setting, as mentioned earlier, often contributes to an unsuccessful reform. A deeper investigation targeting specific language difficulties presented by the textbook is reported in Albadi, O’Toole and Harkins (2017a).

All teachers mentioned the difficulty for students in understanding their physics textbook easily, if they had to catch up on reading through being absent from class for any reason. This issue reflects a difficulty for students in their ability to access the content in their physics textbook. This crucial matter was raised even from the positive teachers who had found this new textbook to be attractive and exciting. Student survey responses indicated ambivalence about being able to extract meaning from the textbook without help, and toward reading about science in general. The style of scientific language used could be the source of this difficulty, as noted above. Students also indicated relatively little enthusiasm about independent reading in general, whether or not it relates to their schoolwork. Some students accessed help with their learning at home, but the overall picture is that they need the teacher’s help to learn effectively.

More experienced teachers in this study admitted to having to employ particular teaching strategies such as reading the physics textbook with their students first and highlighting particular areas that they feel would be difficult for students to understand in their own
reading, thereby simplifying the lesson to enable access to the textbook’s content for all students.

Adequate training and sufficient teacher preparation were other issues raised in this investigation. Although the teachers acknowledged that they did receive training throughout the initial stage of this reform after implementation (El-Deghaidy, Mansour, & Al-Shamrani, 2014), some teachers in this study expressed indifference toward attending the training sessions, as they considered that the program was wasting their valuable class time. Insufficiency and mismanagement of teacher development programs in the beginning of this reform, caused time conflicts with their class lessons and a feeling of inadequacy. Teachers apparently needed more time to engage in collaborative modelling of implementation of the new textbook (El-Deghaidy, Mansour, Al-Dahmash, & Al-Shamrani, 2015). The importance of such effective training workshops was illustrated in Mansour, El-Deghaidy, Al-Shamrani, and Al-Dahmash (2014) who highlight the significance of giving teachers an authentic lesson and allowing them to share and reciprocate their experiences rather than being restricted to just passing on the instructions received directly from the Ministry of Education. Teachers need to be immersed in and instructed on how to shift their teaching method from the traditional one to a student-centered (inquiry-based learning) method (Al-Mazroa, 2013). Some teachers stated that they did not receive any training or instructions before the commencement of the new reform. The more experienced teachers seemed very confident of their ability to teach this new textbook, notwithstanding their negative attitude to it, but cited time constraints as cause for their difficulty in implementing the new collaborative teaching strategies. This finding contrasts with the findings of Al-Ghamdi and Al-Salouli (2012)
which revealed that more experienced teachers were found to be effective and amenable towards the new curriculum.

The experienced teachers in this study relied on their knowledge and past experiences and, therefore, did not tend to refer to resources beyond the textbook. On the contrary, the less experienced teachers more frequently referred to external sources for subject content.

8.9 Conclusions and implications

This current exploratory research investigated the female physics teachers’ and learners’ perceptions toward this new reform with specific attention to their response to the new physics textbook in comparison to the former one, the language used in this textbook, and finally their use of external resources rather than adhere to those solely within the given textbook. Learners’ perceptions were grouped under factors including attitude to physics, school environment, general literacy, physics readability, attitude to science, help at home, and teachers’ Arabic usage.

Many criticisms had emerged from Saudi educators demanding an urgent reform of the Saudi curriculum, in particular science (Al-Tawil, 2013), leading to a new science curriculum reform which started in 2009. Notwithstanding the variety of perceptions among the participants toward the new textbook, the data drawn from the teacher participants suggests that traditional teaching remains the dominant method in this new science reform, at least with regard to physics. Teachers reported that difficulties in shifting their teaching methods were due to insufficient training, insufficient classroom time, excessive class sizes, insufficient ICT equipment and the design of the textbook.
Thus the policy, curriculum intentions, resources and classroom experience do not appear to support each other.

Constructive alignment has five components, enumerated by Biggs (2003, p.26) as “the curriculum, teaching methods, assessments and methods of report result, the climate we create in our interactions with the students, and the institutional climate, rules and procedures we have to follow”. Misalignment of these components in the education system would negatively affect teaching quality. Teacher development and preparation programs to adapt to this new reform criteria should be available (Al-Mazroa & Al-Shamrani, 2015; Hamdan, 2015). The instances of non-alignment of these aspects found in this study illuminate the fact that Saudi policy makers in science education reform have not adequately addressed all alignment components to fulfil the aims of this reform.

The action of borrowing a foreign American physics textbook to inform the redevelopment of a new Arabic physics textbook was another issue that emerged from this study. Participants reported what they felt was unsuitability of adoption of this textbook. Both teachers and students cast doubt on the readability of the Physics textbook. The issues uncovered in the Saudi textbook were twofold and it is evident that this is an area that can yield further information. Firstly, the specialist science language represented in the physics textbook lost its accuracy of meaning through the process of translation from English into Arabic. Secondly, the Modern Standard Arabic used in the textbook differs from the spoken language that the teachers were frequently using in the classroom, consistent with the general patterns of Arabic diglossia. Both issues cause students difficulty in accessing the physics textbook and impact their learning of the Arabic language itself (Al-Mamari, 2011) due to the inadequate Arabic translation of the original English meaning and also the difficulty with understanding the Modern Standard Arabic
text due to the fact that, while it was in their textbook, their teachers were not speaking it in class. In light of these findings, this study highlights the necessity of an integrated and collaborative effort by all stakeholders under the Ministry of Education to fine-tune the problematic issues of the ‘globalizing’ of the physics textbook and the implementation of the new reform, including plenty of opportunities for teachers and learners to have input into the practical implementation of such reform.

Limitations of this study should be noted. The participant sample was restricted to a specific sample of teachers and students, selected for the purpose of comparing across the two groups, and may not be fully representative. It was conducted in a girls’ school due to the cultural values and rules in Saudi Arabia which ensure school gender segregation. While the results are thus not fully generalisable, they are timely in view of recent Saudi policy emphasis on women’s education and careers, and the learning issues that emerged are of likely relevance regardless of the learner’s gender.

It can be concluded from the findings of this study that further research is needed in terms of the policy and preparation for the implementation of this new curriculum, as it should be in alignment with all policy requirement components. Moreover, research could expand the sampling of this investigation into boys’ schools and examine any comparisons between genders. Another key finding is that the language used in Saudi school textbooks is not accessible to different reader ability groups. Therefore it is suggested that language comparisons among written and spoken language varieties be further investigated.
Chapter 9 : Student views of Saudi Physics

9.1 Introduction

This chapter presents results of the analysis of quantitative data from the student questionnaire, building on the general detail and factor analysis presented in the previous chapter. The present chapter offers a fuller account of the backgrounds of participating students and the descriptive results of five different conceptual scales within the questionnaire, followed by a multiple regression based on the previous factor analysis. Planned contrasts investigate the relationship between the student survey responses and their cloze test results.

9.2 Background variables

The first page of the student questionnaire was designed to capture their demographic background. This section provides the frequencies of the background variables for each question.

9.2.1 Place of birth and nationality

Most participating students were from seven Arabic-speaking countries and the majority of these were born in Saudi Arabia. A minority of students were born in non-Arabic speaking countries (See Table 9.1).

Some interesting minor variations are observable between birthplace and citizenship. Notably, over 20% more students were born in Saudi Arabia than held Saudi citizenship. This is almost certainly due to the large foreign workforce residing in Saudi Arabia,
particularly from other Arab countries. The few who were born in Europe are likely to have had parents studying or working there.

Table 9.1: Frequency of student birthplace and nationality

<table>
<thead>
<tr>
<th>Place of birth</th>
<th>No. of students and %</th>
<th>Nationality, by country</th>
<th>No. of students and %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>319 (89.0%)</td>
<td>Saudi Arabia</td>
<td>223 (61.9%)</td>
</tr>
<tr>
<td>Yemen</td>
<td>10 (2.8%)</td>
<td>Yemen</td>
<td>39 (10.8%)</td>
</tr>
<tr>
<td>Jordan</td>
<td>4 (1.1%)</td>
<td>Jordan</td>
<td>7 (1.9%)</td>
</tr>
<tr>
<td>Egypt</td>
<td>8 (2.2%)</td>
<td>Egypt</td>
<td>19 (5.3%)</td>
</tr>
<tr>
<td>Syria</td>
<td>11 (3.1%)</td>
<td>Syria</td>
<td>18 (5.0%)</td>
</tr>
<tr>
<td>Palestine</td>
<td>1 (0.3%)</td>
<td>Palestine</td>
<td>22 (6.1%)</td>
</tr>
<tr>
<td>Sudan</td>
<td>1 (0.3%)</td>
<td>Sudan</td>
<td>17 (4.7%)</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2 (0.6%)</td>
<td>Pakistan</td>
<td>4 (1.1%)</td>
</tr>
<tr>
<td>U.S.A</td>
<td>2 (0.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulgaria</td>
<td>2 (0.6%)</td>
<td>Somalia</td>
<td>2 (0.6%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eritrea</td>
<td>4 (1.1%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chad</td>
<td>1 (0.3%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turkistan</td>
<td>1 (0.3%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Afghanistan</td>
<td>3 (0.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>360 (100%)</td>
<td>Total</td>
<td>360 (100%)</td>
</tr>
</tbody>
</table>

9.2.2 Age and study abroad

Table 9.2 shows that most participating students were between 15 and 16 years of age, which is considered the standard age for Year 10 students. There was a small number of older students, which probably resulted from previous Saudi policy that required failed
students to repeat classes or the delay may have resulted from health issues or other social problems. Table 9.2 also indicates that about one in eight students had previously studied abroad. This is almost certainly connected to the fact that about the same percentage, or 42 of the total sample, were born in another country.
Table 9.2: Student age and prior study abroad

<table>
<thead>
<tr>
<th>No</th>
<th>Variable</th>
<th>Answers</th>
<th>No. and %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>14</td>
<td>1(0.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>115(31.9%)</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>206(57.2%)</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17</td>
<td>32(8.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>4(1.1%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>1(0.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Missing</td>
<td></td>
<td>1(0.3%)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Study abroad</td>
<td>Yes</td>
<td>29(8.1%)</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>327(90.8%)</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td>Missing</td>
<td></td>
<td>4(1.2%)</td>
<td></td>
</tr>
</tbody>
</table>

9.2.3 Parental education

The students’ parents’ level of education varied as shown in Table 9.3.

Table 9.3: Parental education levels

<table>
<thead>
<tr>
<th>Education level</th>
<th>No. (Mother)</th>
<th>No. (Father)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No schooling</td>
<td>51</td>
<td>46</td>
</tr>
<tr>
<td>Informal education</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Secondary Education</td>
<td>115</td>
<td>114</td>
</tr>
<tr>
<td>Less than secondary school</td>
<td>79</td>
<td>53</td>
</tr>
<tr>
<td>Diploma</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Bachelor</td>
<td>63</td>
<td>94</td>
</tr>
<tr>
<td>Master</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>PhD</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>360</td>
</tr>
</tbody>
</table>
More fathers than mothers held a Bachelor, Master or PhD degree. Nearly 25% (a total of 96 out of 360) of mothers held higher education certificates but the majority of mothers had received only secondary education or less. The correlation between higher parental education and higher student cloze test results was discussed in Chapter 7.

9.3 Conceptual scales

The questionnaires used in this study were written based on items forming conceptual scales and the items were then randomly sequenced to form the survey (see Appendix GG). The following tables represent the original *a priori* scales, while retaining the numbers appearing on the survey.

The questions contain five different measurement scales with two criteria of answers: agreement and frequency. To minimise confusion for participants, these were presented to the participants in two groups, with headings indicating agreement and frequency respectively (see Chapter 4). The full questionnaire can be seen in Appendix GG. The five conceptual scales are as follows:

1. Student learning personality, including learning habits and the role of family members in the student’s learning process.

2. Student attitudes toward teachers, a scale designed to elicit the participants’ perspectives about their teacher in general, along with a focus on the style of language used by teachers inside the classroom.

3. Student attitudes to learning in general, indicating the participants’ preferred style of learning whether in school or at home.
4. Student attitudes toward school, focusing on the participants’ opinions of the school facilities and environment.

5. Student attitudes toward the Physics curriculum, with specific focus on the Physics textbook.

The aim of these conceptual scales is to elicit all background information that might give a clear picture of student perspectives and dispositions toward learning Physics. The following tables present each of these scales individually with the agreement questions marked with an asterisk (*) at the end. The percentage values represent the number of student participants choosing this alternative.

**9.3.1 Student learning personality**

Table 9.4 shows the frequency and percentage of student responses to the questions related to their learning personality. More than half of the students responded that they rely on their own efforts when they are doing their homework (almost every day and often) and a very low percentage (2%) answered that they always call on others to help. The second item reinforces this, indicating that half of the students never or rarely call on any of their siblings to help them. This group of students seems to be willing to ask their Physics teacher when they need help: 53.1% report that they don’t hesitate to ask their teacher when they need help, while only 5.3% hesitate to do so. This group of students were ambivalent in their interest in watching new science programs on TV. The families of these students appear to be supportive (51.9% of the total students responding that they receive such support often and almost every day).
Table 9.4: Learning personality: a priori scale

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Almost every day</th>
<th>Often</th>
<th>Sometimes</th>
<th>Not very much</th>
<th>Very rarely</th>
<th>Never</th>
<th>Strongly disagree</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly agree (6)*</td>
<td>Agree (5)*</td>
<td>Agree a little (4)*</td>
<td>Disagree a little (3)*</td>
<td>Disagree (2)*</td>
<td>Strongly disagree (1)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1: I depend on myself in doing my homework and studying.</td>
<td>165</td>
<td>104</td>
<td>65</td>
<td>16</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(45.8%)</td>
<td>(28.9%)</td>
<td>(18.1%)</td>
<td>(4.4%)</td>
<td>(1.9%)</td>
<td>(0.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q23: One of my brothers or sisters helps me in doing my homework and studying.</td>
<td>44</td>
<td>51</td>
<td>52</td>
<td>27</td>
<td>37</td>
<td>144</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(12.2%)</td>
<td>(14.2%)</td>
<td>(14.4%)</td>
<td>(7.5%)</td>
<td>(10.3%)</td>
<td>(40%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q26: I don’t hesitate to ask one of my teachers to help me.</td>
<td>19</td>
<td>32</td>
<td>39</td>
<td>33</td>
<td>45</td>
<td>191</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.3%)</td>
<td>(8.9%)</td>
<td>(10.8%)</td>
<td>(9.2%)</td>
<td>(12.5%)</td>
<td>(53.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5: Before asking my teacher’s help, I would prefer to ask one of my colleagues to help me.</td>
<td>141</td>
<td>85</td>
<td>70</td>
<td>27</td>
<td>20</td>
<td>15</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(39.2%)</td>
<td>(23.6%)</td>
<td>(19.4%)</td>
<td>(7.5%)</td>
<td>(5.6%)</td>
<td>(4.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q32: I don’t hesitate to ask my teacher to re-explain what I don’t understand during the class.</td>
<td>95</td>
<td>70</td>
<td>84</td>
<td>44</td>
<td>34</td>
<td>31</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(26.4%)</td>
<td>(19.4%)</td>
<td>(23.3%)</td>
<td>(12.2%)</td>
<td>(9.4)</td>
<td>(8.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q21: I love to read and observe the updates in science and knowledge and watch the scientific programs on TV.</td>
<td>57</td>
<td>51</td>
<td>65</td>
<td>46</td>
<td>51</td>
<td>89</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(15.8%)</td>
<td>(14.2%)</td>
<td>(18.1%)</td>
<td>(12.8%)</td>
<td>(14.2%)</td>
<td>(24.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q8: My family supports me to excel, succeed, and doesn’t force me to do much housework.</td>
<td>116</td>
<td>71</td>
<td>55</td>
<td>29</td>
<td>36</td>
<td>45</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(32.2%)</td>
<td>(19.7%)</td>
<td>(15.3%)</td>
<td>(8.1%)</td>
<td>(10%)</td>
<td>(12.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q29: I meet with my colleagues outside school to study and do homework.</td>
<td>25(6.9%)</td>
<td>38(10.6%)</td>
<td>51(14.2%)</td>
<td>25(6.9%)</td>
<td>51(14.2%)</td>
<td>163</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(17.2%)</td>
<td>(18.6%)</td>
<td>(18.9%)</td>
<td>(14.2%)</td>
<td>(13.9%)</td>
<td>(45.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q10: I am keen to integrate with excellent students at school.</td>
<td>102(28.3%)</td>
<td>72(20%)</td>
<td>73(20.3%)</td>
<td>59(16.4%)</td>
<td>29(8.1%)</td>
<td>22</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(32.2%)</td>
<td>(19.7%)</td>
<td>(15.3%)</td>
<td>(8.1%)</td>
<td>(10%)</td>
<td>(6.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q17: I read school work.</td>
<td>62</td>
<td>67</td>
<td>68</td>
<td>51</td>
<td>50</td>
<td>62</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(17.2%)</td>
<td>(18.6%)</td>
<td>(18.9%)</td>
<td>(14.2%)</td>
<td>(13.9%)</td>
<td>(17.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q36: I read things that are not connected to school work.</td>
<td>127</td>
<td>49</td>
<td>44</td>
<td>24</td>
<td>39</td>
<td>77</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(35.3%)</td>
<td>(13.6%)</td>
<td>(12.2%)</td>
<td>(6.7%)</td>
<td>(10.8%)</td>
<td>(21.4%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These students rarely met with their friends outside the school to study but 68.6% of participating students liked to integrate with excellent achieving students. Surprisingly, this survey revealed contrasting student attitudes toward reading their school textbook: the same percentage of participants (17.2%), within the two contrasting categories, responding that one group never read school textbooks and another that they read them almost every day. However, these students appear to like reading as 49% reported that they like to read non-school books.

9.3.2 Student attitudes toward teachers

This group of questions aims to measure student attitudes toward their Physics teachers. Table 9.5 shows that more than half of the total participants \((n = 222)\) acknowledge and appreciate (agree and strongly agree) their Physics teachers’ efforts in teaching. The students were ambivalent about their teachers’ English language ability and 45% found that their Physics teachers translate all the physics symbols to the Arabic language. The number of students who disagree and strongly disagree about whether they love Physics because they love their teacher was higher than those who did not. The teachers appear to prefer to use colloquial Arabic language in their classroom rather than MSA. Students have a positive attitude toward their laboratory technician but they reported that the majority of their teachers do not often use technology inside their classroom.
Table 9.5: Attitude to teachers: a priori scale

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Almost every day</th>
<th>Often</th>
<th>Sometimes</th>
<th>Not very much</th>
<th>Very rarely</th>
<th>Never</th>
<th>Strongly disagree</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q38: I appreciate my teacher’s efforts to make Physics an easy course for me.*</td>
<td>116 (32.2%)</td>
<td>106</td>
<td>72</td>
<td>33</td>
<td>9</td>
<td>23</td>
<td>2 (6.4%)</td>
<td>1</td>
</tr>
<tr>
<td>Q42: I love my teacher because she is the one who teaches me.*</td>
<td>72 (20%)</td>
<td>92</td>
<td>71</td>
<td>31</td>
<td>45</td>
<td>42</td>
<td>7 (11.7%)</td>
<td></td>
</tr>
<tr>
<td>Q49: My teacher has a good command of English language.*</td>
<td>64 (17.8%)</td>
<td>65</td>
<td>77</td>
<td>63</td>
<td>36</td>
<td>53</td>
<td>2 (14.7%)</td>
<td></td>
</tr>
<tr>
<td>Q45: I love physics because I love my physics teacher.*</td>
<td>44 (12.2%)</td>
<td>57</td>
<td>62</td>
<td>55</td>
<td>49</td>
<td>83</td>
<td>10 (23.1%)</td>
<td></td>
</tr>
<tr>
<td>Q13: My teacher uses colloquial language inside the classroom.</td>
<td>131 (36.4%)</td>
<td>101</td>
<td>53</td>
<td>28</td>
<td>22</td>
<td>19</td>
<td>6 (5.3%)</td>
<td></td>
</tr>
<tr>
<td>Q7: My teacher uses the classical language (al-fushā) inside the classroom.</td>
<td>38 (10.6%)</td>
<td>75</td>
<td>57</td>
<td>49</td>
<td>39</td>
<td>91</td>
<td>11 (25.3%)</td>
<td></td>
</tr>
<tr>
<td>Q2: The laboratory technician exerts much effort to help us to understand practical sections of the lesson.</td>
<td>145 (10.3%)</td>
<td>71</td>
<td>63</td>
<td>51</td>
<td>16</td>
<td>10</td>
<td>4 (2.8%)</td>
<td></td>
</tr>
<tr>
<td>Q25: My teachers are using technology, teaching aids and power point presentations in teaching scientific courses.</td>
<td>19 (5.3%)</td>
<td>26</td>
<td>44</td>
<td>26</td>
<td>39</td>
<td>201</td>
<td>5 (55.8%)</td>
<td></td>
</tr>
<tr>
<td>Q31: My teacher translates all scientific symbols into Arabic.</td>
<td>99 (27.5%)</td>
<td>63</td>
<td>75</td>
<td>32</td>
<td>36</td>
<td>49</td>
<td>6 (13.6%)</td>
<td></td>
</tr>
</tbody>
</table>
9.3.3 Student attitudes to Physics curriculum

This group of conceptual questions was designed to identify the participating students’ opinions of their Physics textbook, bearing in mind that in the Saudi context the mandatory textbook and the curriculum are regarded as one and the same. These questions (Table 9.6) include the textbook design, ease of understanding the textbook, and the practical lessons guided by it. These students like the lessons taught in the laboratory and they find that doing the experiments, and using colourful designs and figures and graphs help them to understand the Physics lesson. This attitude is unsurprising because these students have a negative attitude in general toward the content clarity of Physics textbooks, but responded that the practical experiments helped them to contextualise the textbook content, so making the lessons easier for them to understand. Students had an ambivalent attitude toward how the laws of Physics are represented in the textbook and 50% of these students indicated that they face difficulty in memorising the Physics symbols in English and that textbook use of the English language made Physics too hard for them to understand. Students who needed to ‘make up’ missed lessons faced further challenges when having to read through missed lesson contents themselves due to having missed the extra support of teacher de-construction of Physics concepts. Only 28% of students indicated that they were able to access the content in the textbook.
Table 9.6: Attitude to curriculum: a priori scale

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Student Response</th>
<th>Number of students (percentage of sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Almost every day</td>
<td>Often</td>
</tr>
<tr>
<td>Q37: I love the scientific lessons which are taught in the laboratory.</td>
<td>94 (26.1%)</td>
<td>129 (35.8%)</td>
</tr>
<tr>
<td>Q46: I like to perform all practical experiments in the laboratory because experiments help me to understand quickly.</td>
<td>172 (47.8%)</td>
<td>81 (22.5%)</td>
</tr>
<tr>
<td>Q48: The Physics book is clear and interesting.</td>
<td>19 (5.3%)</td>
<td>36 (10%)</td>
</tr>
<tr>
<td>Q41: Laws in the Physics book are expressed in a very simplified way.</td>
<td>43 (11.9%)</td>
<td>66 (18.3%)</td>
</tr>
<tr>
<td>Q14: I can understand and memorise the physics symbols in English easily.</td>
<td>39 (10.8%)</td>
<td>63 (17.5%)</td>
</tr>
<tr>
<td>Q16: The colorful design of the Physics book helps me to understand.</td>
<td>140 (38.9%)</td>
<td>89 (24.7%)</td>
</tr>
<tr>
<td>Q9: Figures and graphs in the Physics book help me to understand.</td>
<td>88 (24.4%)</td>
<td>68 (18.9%)</td>
</tr>
<tr>
<td>Q27: Using English in the Physics book makes it more difficult.</td>
<td>130 (36.1%)</td>
<td>60 (19.7%)</td>
</tr>
<tr>
<td>Q20: I can understand lessons which I couldn’t attend at school through reading the textbook.</td>
<td>26 (7.2%)</td>
<td>59 (16.4%)</td>
</tr>
<tr>
<td>Q3: I can extract the main information of a Physics lesson through reading the textbook.</td>
<td>62 (17.2%)</td>
<td>82 (22.8%)</td>
</tr>
</tbody>
</table>
9.3.4 Student attitudes toward school

This conceptual scale (Table 9.7) aimed to discover the environment around students in their school and the extent to which the school, library and the laboratory provide the equipment that they need. Student responses suggested that they liked their school as they found it very comfortable and they indicated that the school had a good supply of resources such as good quality tools used in Physics experiments, and an adequate amount of safety equipment inside the laboratory. On the contrary, however, students had a negative opinion regarding the availability of materials in their school library. Despite the provision of equipment in their classrooms, however, they seemed to not be interested in conducting any scientific activities. Contrastingly, the student participants, particularly the high performing students, found their teachers to be very supportive of their learning.

9.3.5 Student attitudes to learning in general

The last group of conceptual questions is targeted to identify student learning habits and dispositions (Table 9.8). Responses indicate that this group of students is willing to do research work, and are curious about new scientific inventions. The majority of the participating students prefer to use simpler textbooks, have private tutors, and use course summaries to help them to understand the physics concepts, but they are not keen to search for and watch any educational program at home. Students in this study are aware that teachers’ use of technology in their teaching pedagogy helps them to understand the lessons. Unsurprisingly, students responded negatively to the item of the use of foreign language textbooks in a quest to help them understand their Physics lesson, which is clearly apparent when they reported the difficulties of including English language in their textbook.
Table 9.7: Attitude to school: a priori scale

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Student Response</th>
<th>Number of students (percentage of sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Almost every day</td>
<td>Often</td>
</tr>
<tr>
<td>Strongly agree (6)*</td>
<td>57 (15.8%)</td>
<td>71 (19.7%)</td>
</tr>
<tr>
<td>Agree (5)*</td>
<td>71</td>
<td>71 (19.7%)</td>
</tr>
<tr>
<td>Little agree (4)*</td>
<td>57 (15.8%)</td>
<td>57 (15.8%)</td>
</tr>
<tr>
<td>Not very much</td>
<td>32 (8.9%)</td>
<td>32 (8.9%)</td>
</tr>
<tr>
<td>Very rarely</td>
<td>39 (10.8%)</td>
<td>39 (10.8%)</td>
</tr>
<tr>
<td>Never</td>
<td>100 (27.8%)</td>
<td>100 (27.8%)</td>
</tr>
<tr>
<td>Missing data</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Q43: School is my second home.*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q47: My school offers safety equipment in laboratories.*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q39: My school offers a well-equipped laboratory for physics experiments.*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q15: The physics laboratory has most of the necessary equipment for physics experiments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6: My school’s library offers all required references.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q22: There is a very convenient educational environment in my school.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q11: I love scientific activities which are held in our school and I take part in them.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q34: My teachers support and encourage excellent students.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q19: Classrooms in my school are equipped with teaching aids, computers, and data show projectors to help us understand the scientific subjects.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Table 9.8: Attitude to learning: a priori scale

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Almost every day</th>
<th>Often</th>
<th>Sometimes</th>
<th>Not very much</th>
<th>Very rarely</th>
<th>Never</th>
<th>Missing data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly agree (6)*</td>
<td>Agree (5)*</td>
<td>Like (4)*</td>
<td>Disagree (3)*</td>
<td>Disagree (2)*</td>
<td>Strongly disagree (1)*</td>
<td></td>
</tr>
<tr>
<td>Q40: It is okay for me to do research papers when my teachers ask for that.*</td>
<td>41 (11.4%)</td>
<td>91 (25.3%)</td>
<td>87 (24.2%)</td>
<td>66 (18.3%)</td>
<td>32 (8.9%)</td>
<td>41 (11.4%)</td>
<td>2</td>
</tr>
<tr>
<td>Q44: I love to know more about the latest inventions all over the world.*</td>
<td>112 (31.1%)</td>
<td>65 (18.1%)</td>
<td>72 (20%)</td>
<td>30 (8.3%)</td>
<td>30 (8.3%)</td>
<td>43 (11.9%)</td>
<td>8</td>
</tr>
<tr>
<td>Q50: I buy some commercial books from book stores to simplify studying.*</td>
<td>47 (13.1%)</td>
<td>51 (14.2%)</td>
<td>16 (16.9%)</td>
<td>36 (10%)</td>
<td>50 (13.9%)</td>
<td>113 (31.4%)</td>
<td>47</td>
</tr>
<tr>
<td>Q18: I like the use of PowerPoint shows in teaching.</td>
<td>157 (43.6%)</td>
<td>74 (20.6%)</td>
<td>46 (12.8%)</td>
<td>25 (6.9%)</td>
<td>17 (4.7%)</td>
<td>14 (11.4%)</td>
<td>27</td>
</tr>
<tr>
<td>Q24: I like the use of video clips in teaching.</td>
<td>129 (35.8%)</td>
<td>55 (15.3%)</td>
<td>43 (11.9%)</td>
<td>40 (11.1%)</td>
<td>41 (11.4%)</td>
<td>49 (13.6%)</td>
<td>3</td>
</tr>
<tr>
<td>Q4: I attend some private tutoring when required.</td>
<td>19 (5.3%)</td>
<td>32 (8.9%)</td>
<td>39 (10.8%)</td>
<td>33 (9.2%)</td>
<td>45 (12.5%)</td>
<td>191 (53.1%)</td>
<td>3</td>
</tr>
<tr>
<td>Q28: I prefer to study from prepared course summaries, not from the official textbooks.</td>
<td>233 (64.7%)</td>
<td>42 (11.7%)</td>
<td>30 (8.3%)</td>
<td>15 (4.2%)</td>
<td>12 (3.3%)</td>
<td>23 (6.4%)</td>
<td>5</td>
</tr>
<tr>
<td>Q33: I love to watch educational programs at home.</td>
<td>50 (13.9%)</td>
<td>32 (8.9%)</td>
<td>56 (15.6%)</td>
<td>47 (13.1%)</td>
<td>64 (17.8%)</td>
<td>106 (29.4%)</td>
<td>5</td>
</tr>
<tr>
<td>Q35: I use some foreign materials and Arabic references in studying.</td>
<td>39 (10.8%)</td>
<td>43 (11.9%)</td>
<td>68 (18.9%)</td>
<td>53 (14.7%)</td>
<td>42 (11.7%)</td>
<td>112 (31.1%)</td>
<td>3</td>
</tr>
</tbody>
</table>
9.4 Multiple regression

The multiple regression technique examines the relationship between dependent variables and two or more independent variables. The data generated from the factor analysis (see Chapter 8) was useful to establish the correlation between the surrogate item factor and the students’ conceptual results from the cloze test. The use of stepwise regressions was used to explore further correlations in the data.

The first step identifies the descriptive statistics based on the seven factors and students’ conceptual cloze scores.

Table 9.9: Descriptive statistics:

Factors against mean conceptual total score on cloze test

<table>
<thead>
<tr>
<th>Student response scale</th>
<th>Mean conceptual Total /50</th>
<th>Standard deviation of distribution</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total conceptual replacement</td>
<td>17.44</td>
<td>8.478</td>
<td>341</td>
</tr>
<tr>
<td>Positive attitude to learning Physics</td>
<td>10.64</td>
<td>1.214</td>
<td>341</td>
</tr>
<tr>
<td>Supportive school environment</td>
<td>10.03</td>
<td>1.692</td>
<td>341</td>
</tr>
<tr>
<td>General literacy</td>
<td>9.94</td>
<td>1.983</td>
<td>341</td>
</tr>
<tr>
<td>Physics readability</td>
<td>9.16</td>
<td>1.620</td>
<td>341</td>
</tr>
<tr>
<td>Positive attitude toward Science</td>
<td>9.32</td>
<td>1.797</td>
<td>341</td>
</tr>
<tr>
<td>Help at home</td>
<td>8.86</td>
<td>1.873</td>
<td>341</td>
</tr>
<tr>
<td>Teacher uses MSA</td>
<td>9.28</td>
<td>1.756</td>
<td>341</td>
</tr>
</tbody>
</table>

Table 9.9 provides the mean and standard deviation for the groups of students sorted by the student response scale. The overall mean score for the students’ total conceptual
replacements (17.44/50) provides a basis of comparison between the student groups. For example, the average score of 10.64/50 for ‘Positive attitude toward learning Physics’, compared to an average score of 8.86 /50 for ‘Help at home’ suggests that individual student attitudes may be a more important indicator of ease in access to their Physics text than the amount of help that they receive at home, but that both groups appear to have more than average difficulty in accessing the text.

The second step involved correlation of the various factors (Table 9.10). The purpose of stepwise multiple regressions was to establish the relationship between the students’ cloze test (total conceptual replacement) and the factors reduced from the 47 items on the conceptual scale to the seven factors. Table 9.11 shows the multiple correlation coefficient of model 2 which explains 2.3% of the variance with two of the surrogate variables included. This approaches a medium effect size: $0.0196 < R^2 (= 0.094) < 0.13$ (Allen & Bennett, 2010, p. 187).

The regression equation for model 2 can be extracted from Table 9.13 as shown below:

Conceptual total = 18.934 – 0.881 * Help at home (‘score’ from 1 to 6) + 0.690 * Physics readability (‘score’ from 1-6);

where 6 is strong positive and 1 is low positive.

This regression equation yields a medium effect size and is therefore adequate for further discussion. It can be used to suggest the impact of the factors that the regression calculation indicated as making a significant difference to student performance on the cloze test based on a sample from the mandatory Year 10 Physics text. It appears that help at home and the perceived readability of the Physics text both sort the student scores into different groups. Table 9.14 suggests the influences that these factors might exert.
Table 9.10: Correlation of factors

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total conceptual replacement</th>
<th>Positive attitude to learning Physics</th>
<th>Supportive school environment</th>
<th>General literacy</th>
<th>Physics readability</th>
<th>Positive attitude toward Science</th>
<th>Help at home</th>
<th>Teacher uses M.S.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total conceptual replacement</td>
<td>1.000</td>
<td>.039</td>
<td>.065</td>
<td>.091</td>
<td>.127</td>
<td>.020</td>
<td>-.191</td>
<td>.004</td>
</tr>
<tr>
<td>Positive attitude to learning Physics</td>
<td>.039</td>
<td>1.000</td>
<td>.128</td>
<td>.155</td>
<td>.164</td>
<td>.143</td>
<td>.040</td>
<td>.041</td>
</tr>
<tr>
<td>Supportive school environment</td>
<td>.065</td>
<td>.128</td>
<td>1.000</td>
<td>.100</td>
<td>.114</td>
<td>.158</td>
<td>.008</td>
<td>.214</td>
</tr>
<tr>
<td>General literacy</td>
<td>.091</td>
<td>.155</td>
<td>.100</td>
<td>1.000</td>
<td>.153</td>
<td>.200</td>
<td>-.031</td>
<td>.111</td>
</tr>
<tr>
<td>Physics readability</td>
<td>.127</td>
<td>.164</td>
<td>.114</td>
<td>.153</td>
<td>1.000</td>
<td>.136</td>
<td>.024</td>
<td>.031</td>
</tr>
<tr>
<td>Positive attitude toward science</td>
<td>.020</td>
<td>.143</td>
<td>.158</td>
<td>.200</td>
<td>.136</td>
<td>1.000</td>
<td>.008</td>
<td>.143</td>
</tr>
<tr>
<td>Help at home</td>
<td>-.191</td>
<td>.040</td>
<td>.008</td>
<td>-.031</td>
<td>.024</td>
<td>.008</td>
<td>1.000</td>
<td>.016</td>
</tr>
<tr>
<td>Teacher uses M.S.A</td>
<td>.004</td>
<td>.041</td>
<td>.214</td>
<td>.111</td>
<td>.031</td>
<td>.143</td>
<td>.016</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Multiple regression of these correlations produced a number of explanatory models.

Table 9.11: Model summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted Square</th>
<th>R</th>
<th>Std.Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.1910a</td>
<td>.037</td>
<td>.034</td>
<td>8.334</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.232b</td>
<td>.054</td>
<td>.048</td>
<td>8.270</td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (constant), Help at home
b. Predictors: (constant), Physics readability

Table 9.12: ANOVA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>896.272</td>
<td>1</td>
<td>896.727</td>
<td>12.904</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>23545.863</td>
<td>339</td>
<td>69.457</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>24442.135</td>
<td>340</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Regression</td>
<td>1320.618</td>
<td>2</td>
<td>660.309</td>
<td>9.653</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>2312.517</td>
<td>338</td>
<td>68.407</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>24442.135</td>
<td>340</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: total conceptual replacement
b. Predictors: (Constant), Help at home
c. Predictors: (Constant), Help at home, Physics readability

Table 9.13: Coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardised B</th>
<th>Coefficients Std. Error</th>
<th>Standardised Coefficients Beta</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>25.129</td>
<td>2.187</td>
<td>-.191</td>
<td>-3.592</td>
</tr>
<tr>
<td></td>
<td>Help at home</td>
<td>-.867</td>
<td>.241</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>(Constant)</td>
<td>18.934</td>
<td>3.301</td>
<td>-.195</td>
<td>-3.678</td>
</tr>
<tr>
<td></td>
<td>Help at home</td>
<td>-.881</td>
<td>.240</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physics readability</td>
<td>.690</td>
<td>.277</td>
<td>.132</td>
<td>2.491</td>
</tr>
</tbody>
</table>

a. Dependent Variable: total conceptual replacement
Table 9.14: Impact of influential scales, where 6 is strong positive and 1 is low positive

<table>
<thead>
<tr>
<th>Conceptual replacement out of 50</th>
<th>Constant</th>
<th>β Help at home</th>
<th>Value of help at home</th>
<th>B Physics readability</th>
<th>Value of Physics readability</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A): 14.334</td>
<td>18.93</td>
<td>-0.881</td>
<td>6</td>
<td>0.690</td>
<td>1</td>
</tr>
<tr>
<td>(B): 17.784</td>
<td>18.93</td>
<td>-0.881</td>
<td>6</td>
<td>0.690</td>
<td>6</td>
</tr>
<tr>
<td>(C): 22.189</td>
<td>18.93</td>
<td>0.690</td>
<td>1</td>
<td>0.690</td>
<td>6</td>
</tr>
<tr>
<td>(D): 18.739</td>
<td>18.93</td>
<td>0.690</td>
<td>1</td>
<td>0.690</td>
<td>1</td>
</tr>
</tbody>
</table>

Frequent help, Physics textbook hard to read
Frequent help, textbook easy to read
Little help, Physics textbook easy to read
Little help, textbook hard to read

Table 9.14 allows suggestions of interactions. If a student reported strong help from home, and they found the Physics textbook hard to read (Group A) they would score around 28% \[18.934 – (0.881 * 6) + (0.690 * 1) = 14.334 / 50\]. There are other possibilities: if a student reported strong help from home, and they find the Physics textbook easy to read (Group B) they would score around 36% on the cloze test. If the students didn’t get help from home but they reported that the Physics textbook is easy to read (Group C) they would get the highest score of 44%.
If the students reported that they didn’t get help at home and the Physics textbook is hard to read (Group D) they would score 37%. This may seem counter-intuitive but it reinforces the validity of the methodology used in this study. The students stating that they can read the book on which the cloze test is based performed most successfully on that test, even without any additional help.

9.5 Planned contrast

The interactions between student and teacher responses and between student responses and student cloze scores are potentially interesting. Planned contrasts allow investigation of the relationship between individual student answers to specific survey questions and the average cloze score scores of the group of such students participating in this study. Variables which produced statistically significant differences in average cloze score were contrasted.

Table 9.15 shows the questions where there was a significant difference in cloze scores across the student group, according to their response to the item. The arrow appearing next to the range of conceptual total cloze scores indicates whether the scores rose or fell with a positive response to the question. For example, self-reliant students (Q 1, first on Table 9.13) scored more highly than less self-reliant students but those who report private tutoring (Q 4, second on Table 9.13) did not score as highly as those without such access. The group of Saudi students who seem to enjoy the lessons which are taught in the laboratories, and that they consider safe environments for learning, achieved higher scores in their cloze test. These students also reported willingness to ask their teacher to re-explain any vague points and they mentioned that their Physics teachers had a good
background of English language and were supportive of excellent students. More highly scoring students seem to be self-reliant, not reporting help from family members and they found that the design of the Physics textbook helped them to study.

Table 9.15 Planned contrasts

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range of conceptual score (50)</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 I depend on myself in doing my homework and studying.</td>
<td>5-19</td>
<td>0.000</td>
</tr>
<tr>
<td>Q4 I attend some private tutoring when required.</td>
<td>19-14</td>
<td>0.008</td>
</tr>
<tr>
<td>Q16 Colorful design of the Physics book helps me to understand.</td>
<td>18-19</td>
<td>.031</td>
</tr>
<tr>
<td>Q23 One of my brothers or sisters helps me in doing my homework and studying.</td>
<td>19-15</td>
<td>.035</td>
</tr>
<tr>
<td>Q32 I don’t hesitate to ask my teacher to re-explain what I don’t understand during the class.</td>
<td>13-19</td>
<td>.015</td>
</tr>
<tr>
<td>Q34 My teachers support and encourage excellent students</td>
<td>14-20</td>
<td>.003</td>
</tr>
<tr>
<td>Q46 I like to perform all practical experiments in the laboratory because experiments help me to understand quickly.</td>
<td>14-19</td>
<td>.027</td>
</tr>
<tr>
<td>Q47 My school offers safety equipment in laboratories</td>
<td>14-19</td>
<td>.027</td>
</tr>
<tr>
<td>Q49 My teacher has a good command of the English language</td>
<td>14-20</td>
<td>.001</td>
</tr>
</tbody>
</table>

9.6 Conclusion

This concluding section provides a bridge between the results of the student survey and the discussion section in the following chapter, which draws together all of the results emerging from this study. The survey results presented above have identified several new
aspects of student backgrounds that apparently impact on reading performance (Research Question 5). The application of factor analysis to these results in Chapter 8 allowed triangulation with the results obtained from teacher interviews. The following, final chapter includes linking of these students’ responses, their cloze results, and issues that have emerged throughout the extended discussion that comprises this thesis.
10.1 Overview of results

The results of this mixed method research were presented in a series of four published articles; each focussing on one or two of the research questions. This sequence of publications is presented as Chapters 4-8, and is followed by a fuller exploration in Chapter 9 of the surveyed students’ views of their experience in Year 10 Physics. Together, these publications and the analysis of the student survey have provided a clear picture of current issues in the field of science education in Saudi Arabia and other MENA countries. The discussion has moved from science education in English, through science education in Arabic, to the specific Saudi situation where contemporary instructional resources use English terminology embedded in Arabic text. This overview of how the parts of the study fit together is followed by discussion of the key findings under each of the three research objectives: Saudi Physics text, student reading difficulties, and the broader context of student and teacher perceptions of learning Physics in Saudi Arabia.

This study initially considered whether the Arabic text that Year 10 students encounter in their Physics books was comparable in difficulty with other text that they might encounter in other subjects. To obtain a value ranking, expert Arabic teachers were asked to evaluate these passages on a scale of simpler to more difficult for Year 10 readers. The Physics passage was rated as the most difficult one. Key findings on text difficulty are further discussed below.
The next objective was to discover whether there was a problem for learners with the language used in the Year 10 Physics textbook. A small number of student participants were given a cloze test to provide another perspective on the outcomes from the first study. The results were congruent with the results obtained from the first study and established a number of specific language difficulties features. With an increased number of participants, the larger study then used a more precise word classification approach to identify any other specific features of the language which caused particular problems. The results indicated that the range of these specific features was narrower than that revealed in the research on English science literacy. A further aim of this study was to identify any impact that Arabic dialectal variation may have had on the study results. Unexpectedly, the comparison between Jeddah and Abha students showed that regional variation between those two cities did not seem to affect their cloze test results, but that the divergence between spoken and written Arabic is more likely be an issue.

The final research objective was to gain further insight into this situation by eliciting the teachers’ and students’ experiences and perceptions in regard to the recent changes in the Saudi Year 10 Physics curriculum and textbook. This deeper exploration was useful in identifying opinions, thoughts, and implications, and indicated that teachers and students shared many similar concerns. The results also revealed some discrepancy between the views of more and less experienced teachers.

In 2014, the Saudi Ministry of Education launched an evaluation program which measured student educational performance. This evaluation reported that 70% of students achieved low performance levels in reading and writing (Al-Najim, 2016). The present study yielded similar results to those of that evaluation program, in the specific area of
10.2 Objective one: Saudi Physics Text

10.2.1 Key findings: Readability across school subjects

Response to the research question:

“Do text samples drawn from textbooks for a range of Saudi Year 10 subjects differ in readability?”

The purpose of the first investigation of this study was to obtain the opinion of experts on different reading passages. Ninety-four expert Arabic teachers were asked to read as though they were Year 10 students, and to rank four authentic passages extracted from Year 10 textbooks, including the Physics passage later used to produce a cloze test (see Appendices P to U). Arabic expert teachers used a five point scale to rank these passages according to their perceived readability level. The use of the experts’ judgments was an effective way to identify and locate problems in particular texts. The expert responses suggested that the passages differed in difficulty. Their perceptions differed but clear indications of relative difficulty emerged from analysis of group results (see Chapter 5).

This finding suggests that expert judgment, especially that provided by more experienced Arabic language teachers, could lead to an increased awareness of readability difficulties in textbooks using the Arabic language as the medium of instruction. Such experts have been involved in checking the validity of cloze passages (see Appendix B) but more rarely in determining text grading in Arabic literature.
10.2.2 Key findings: Physics text readability

Response to the research question:

“Do experts in the Arabic language rate Year 10 Saudi science texts as relatively hard for students to read?”

This investigation aimed to ascertain which passages might have a higher risk of reading difficulty than others. The results of this investigation clearly indicated that the Physics passage would be harder to read, followed by the Biology passage, as compared to the Arabic grammar and Geography passages (see Chapter 5). This finding suggests the need for focus on science textbooks and the Physics textbook specifically.

These results are particularly illuminative in light of the inconsistency in ranking results obtained from applying the Arabic readability formulas of Al-Heeti (1984) and Al-Tamimi et al. (2013) to the four passages. These contradictory results were another reason for consulting the opinions of expert teachers. Research on measuring levels of readability in the Arabic language is less advanced than similar research in other languages such as English. An effective and reliable tool to estimate the level of a text’s readability is vital to sound, evidence-based educational decision making.

This study revealed that while some formulas have been devised to measure the readability of written texts in Arabic, these formulas have not been used in an effective way. All of the available formulas to measure Arabic text readability have been based on such features as sentence, length or word repetition and the number of words per sentence without consideration of the language features of the Arabic language, especially grammar. Several studies which measured the readability level for the Arabic language
textbook using the cloze technique revealed low performance scores of students (see Chapter 3). These results are an indication of the importance of developing an effective tool that can be used to measure readability levels which takes the Arabic language and its grammar into consideration.

10.3 Objective two: Student difficulties with Physics text

10.3.1 Key findings: Measurement of Physics text difficulty

Response to the research question:

“Do some Saudi students have trouble in reading a mandatory science textbook?”

Both the pilot study and the full study addressed the matter of reading Physics and science textbooks, by using the cloze test method (see Chapters 7 and 8). A number of studies in the Arabic research literature have shown various textbooks to be hard for students to read, in terms of being rated at frustration level and consequently beyond the students’ reading ability (see Chapter 4). However, none of the previous studies sought to identify the specific causes of this reading difficulty. The studies reported in both in Chapters 6 and 7 closely focussed on identifying the features associated with this well-established reading difficulty.

10.3.2 Key findings: Patterns of Physics text reading difficulty

Response to the research question:

“Does close linguistic analysis of Saudi student replacement of regular deletions from an authentic physics text reveal a pattern of language difficulty?”
The results obtained from both studies reported in Chapters 6 and 7 were clearly able to indicate specific language feature difficulties in the particular Physics textbook. The pilot study involved 80 students in one city. The larger study presented in Chapter 7 had increased the size of the sample and conducted the study in two different cities rather than one. Expanding the study gave the opportunity for comparison between the two cities and to discover further details that could assist in recognizing the style of language used in the Physics textbook and to measure the level of student reading ability.

The two studies each used different approaches in deleting words to produce cloze gaps which produced an inconsistency in results of difficulties associated with language features. However, the findings from both studies agreed in confirming that reading and comprehending the text can be regarded as a major learning difficulty for Year 10 students and that patterns of difficulty can be identified.

The participants in both studies experienced difficulty with the technical words targeted by cloze deletion. These results were expected because Physics is known to be dense in technical terms (R. Al-Ghamdi, 2017). Such difficulties can be expected as they are regarded as one of the major language features of the Physics and science language, in Arabic as well as in other languages. However, the results of this study suggest that the difficulties found with reading the Physics textbook are not limited to those associated with the technical language as has been previously asserted (Jurdak & Sawaya, 1980). Arabic language features have been identified in both studies as indicators of some of the causes of difficulties experienced by students when attempting to access this Physics textbook. They still remain a barrier for the learners to engage effectively in this subject.
Chapter 6 shows indicates that students face difficulty in reading their Physics text and Chapter 7 provides a more thorough investigation of the phenomenon.

### 10.3.3 Key findings: Readability issues in Arabic versus English

“Does any such pattern match existing data on the problems faced by English-speaking students with the language of their science books?”

Chapter 6 presented an initial study to determine whether the language in the Physics textbook causes difficulty for Saudi Year 10 students, and to compare this with the results of cloze testing with English language science students. Despite the small number of 80 participating students, the results were useful in identifying language from this particular textbook that could affect student comprehension. The low percentage of conceptually correct responses (28%) from the Saudi students’ cloze test compared to the English students ($M = 62\%$) indicated that language is a cause for concern in both groups (see Figure 6.1).

The difficulty of reading in general for Saudi students has been the focus of much Saudi education literature. However, there has been little specific attention to reading in science and increasing the levels of scientific literacy in Saudi science education. A decade ago, Amin (2009) had already identified this as a gap in the literature related to Middle Eastern science education in general.

Although the Islamic culture encourages people to read, insofar as the first verse that was revealed to Prophet Mohammed (Peace Be Upon Him) was the imperative “Read!”, the habit of reading has not become popular either in Saudi Arabia, nor elsewhere in the Arab world (see Section 2.2.6). According to the new Arab Reading Index, Arabs read an average of 35 hours per year. The results of an online survey of about 148,000 participants
representing 22 Arab states obviously indicates that poor reading habits in the area are due to a lack of interest in reading (Zakaria, 2016). While not necessarily reliable, as it relies on self-report, the survey also indicates that of this average of 35 hours per year, 15 of those hours are related to work or study. The remaining 20 hours can presumably be associated with recreational reading (Al-Najim, 2016; Khaleej Times, 2016).

The Ministry of Education endeavoured to improve the quality of the science textbook by producing an Arabic version of the American textbook to develop students’ ability in thinking scientifically and critically and in problem-solving (Boujaoude & Gholam, 2014). This study’s findings indicate that further improvement could flow from more specific attention to readability issues. Moreover, encouraging students to read from an early stage will improve their reading comprehension skills. Solid reading skills will lead to more effective learning across different subjects (Al-Najim, 2016).

10.4 Objective three: Background and perceptions

10.4.1 Key findings: Student background factors

Response to the research question:

“How do prior knowledge, language variety and parental education influence student performance when reading?”

The cloze results obtained from the pilot study indicated low performance in student cloze answers (14.03/50) for a group of students who had covered the content before the language test. Similar results were obtained from the larger study: there was no statistical difference between the results of the one class who had covered the content and the five
classes which had not. This indicates that the language style used in Physics textbooks presents reading difficulty that may not be reduced by prior knowledge.

Parent education appeared important in student achievement with statistically significant correlation between parental education level and student cloze score (see Chapter 7). This is unsurprising given the value Islam places on learning and its role in Saudi society.

Saudi students made up the majority of participants in this study and they appeared to have moderate difficulty with this Physics text compared to those drawn from the other 12 nationalities represented. This study indicated that there were significant connections between the students’ nationalities, their age and their cloze results (see Chapter 7). However, more surprisingly, the results of the wider study indicate that dialect did not have a significant impact on access to this Physics text by these students.

10.4.2 Key findings: Teacher and learner perceptions

Response to the research question:

“What are the teachers’ and learners’ perceptions of the latest Saudi science education reform with specific relation to physics, particularly in terms of the style of written language in the textbook and of the new teaching strategies that are required?”

Chapters 8 and 9 addressed the reactions of Physics teachers and students to the recent changes in science teaching in Saudi Arabia. Interview data suggests that less experienced teachers preferred the new textbook, but all doubted the applicability to Saudi Physics classes of the new teaching strategies integral to its implementation.
The more experienced teachers had a negative attitude toward this new reform. They recognised the writing issue in the Physics textbook and their previous experience allowed them to critically evaluate the current textbook and notice the language difficulties. Less experienced teachers did not raise this issue as they found this textbook an improvement over the previous one, believing that the language issue did not cause noticeable difficulties for students.

Opinions expressed by the more experienced teachers were similar to those of the students in response to the question about the clarity of the language in the Physics textbook (see question 48 in Chapter 9). The poor student performance on the cloze results, from both initial and wider studies, supports negative student responses regarding the readability of the textbook. The negative response of experienced teachers may not be mere recalcitrance.

These chapters also drew attention to the mandatory inclusion of English language Physics terminology and units within this Arabic textbook (see Fig. 2.1). This innovation proved problematic in the initial stages of implementing the textbook. However, the situation improved as both groups of teachers became more familiar with the English terms. However, the more experienced teachers acknowledged that the inclusion of English language was not particularly helpful and that it created another concern about this Physics textbook. Students also suggested that the English language was a barrier to their use of the Physics textbook. It appears that the more experienced teachers found that the language of the Physics textbook was beyond their students’ capability. These more experienced teachers tackled the problems in the Physics textbook by reading the lesson from the textbook with the students, helping them to highlight the important points and
giving the students a summary sheet to simplify the lesson for them. These teachers admitted that they had not felt it necessary to use those techniques with the previous textbook.

Students and both groups of teachers agreed that reading the lesson from the textbook without attending the class was unproductive as the style of language used in the Physics textbook was not appropriate to the students’ level of reading ability. The students needed to attend the class to be able to understand the lesson and teachers suggested that even use in class was problematic.

There was a correlation between students’ positive reaction to the Physics textbook’s design and their cloze test performance, indicating that if they were comfortable with the style of presentation, they were more likely to comprehend the subject matter of the text. Student participants’ preference for the more active learning style was indicated by the association of higher cloze test results with a positive attitude to performing experiments in the school laboratory.

The results obtained from the student survey clarify some important aspects of the students’ learning behaviours. The student participants who were self-reliant, did not depend on any help from home, and had the confidence to ask their teachers for help, achieved higher marks in their cloze results. This clearly illustrates that a student’s self-confidence impacts positively on their science achievement (cf. Britner, 2008).

The results showed a positive impact of teachers’ support and proficiency in the English language on student results in the cloze test. However, outcomes from the teacher interviews indicated contradictory opinions toward implementing the new science
textbook. Teacher preparation, laboratories, classroom equipment, teaching style and policy makers are all important components in developing science education. A teacher’s style of teaching can impact either negatively or positively on a student’s scientific achievement (R. Al-Ghamdi, 2017; Goddard, Hoy, & Hoy, 2000). Many teachers find it difficult to change their style of teaching. The barriers that have been discussed in Chapter 8 indicate that essential reform in pre-service teacher training is required.

10.5 Toward an improved development model

Science is recognised by Saudi educators and policy-makers as an essential subject at all school levels. Many Saudi girls prefer to study the science topics related to Biology and Medicine (R. Al-Ghamdi, 2017). Physics attracts fewer Saudi girls, as is the case for girls internationally (Stadler, Duit, & Benke, 2000). Physics contains a wide range of mathematical and complex natural concepts. Efforts by teachers to integrate these concepts into students’ daily lives are increasing learners’ interest in science in general and Physics in particular (A. Al-Ghamdi, 2017). In line with the new Saudi Vision 2030, Dr. Ahmed Al-Issa, the Minister of the Saudi Education department, recently launched a new project called ‘Future gate’. The main idea of this project is to develop technology in the educational field. One of the goals of this new initiative is to improve student reading and writing ability. Moreover, this project aims to improve teaching methods from the traditional to a more active and communicative style between students and teachers (IEN E-Newspaper, 2017). Implementing this project, together with recognition of students’ overall low achievement in reading, writing, and the need for teacher preparation, could help to achieve the goals of Saudi science education.
The findings from the various aspects of this study of Year 10 Physics suggest a model for the development of Saudi science education. The model has three components: Access to the Textbook; Teacher Qualifications; and the Impact of Local Culture on the Learner.

Teacher qualifications and preparation are basic components of the model. If the teachers have the ability to teach, this will positively affect the students’ interest and achievement. The textbook is one of the major resources provided to teachers and this makes student access crucial. Both of these components interact with the local educational and learning culture, which is becoming more fluid in the Saudi context. The learning experience offered to Saudi science students is formed by the dynamic tension between these components. This model is intended to foster constructive alignment among all relevant components in Saudi science education.

Figure 10.1: Proposed Albadi model for progress in Saudi science education.

This discussion thus far has reviewed the key findings on the existing pattern of specialist language used in the Year 10 Physics textbook, and what these findings reveal about the
basic question, ‘What makes the Physics textbook difficult to read?’ Factors inherent in several components of the Saudi education system, teachers, students, policy and culture, have been identified in addition to specific difficulties of accessing the Physics textbook itself. A new model has been proposed to address these multiple factors. The most recent Saudi science education literature confirms that these are important topics for further discussion directed toward positive action. The present study has certain limitations of the kind inherent in any single piece of research, but it nonetheless offers some important and promising implications for Saudi science education policy, practice and research.

10.6 Limitations

Although this research has accomplished its purpose, several methodological limitations were unavoidable. These limitations of the study have been discussed in detail in each publication, and are summarised here.

As mentioned in the Methodology discussion, this research was restricted to female participants only. This serves to partly redress the balance in Saudi education research, where more studies have focussed on male than female students, and these results will enrich further studies with broader populations. They provide a basis for deeper research in many aspects of education and will help to achieve some of the Saudi Vision 2030. One of the visions is to increase employment and empower women in all governmental and private sectors.

Another limitation is the inconsistency between word divisions in the two cloze test studies, reported in Chapters 6 and 7. Identification of words based on white spaces, versus division of clitic morphemes from a base word, yielded somewhat different
identifications of language features which caused reading obstacles. There are differences in the mean score of the conceptually correct answers and therefore, the results of the two studies (Chapter 6, $M = 28\%$, Chapter 7, $M = 34.44\%$). Yet both of these studies showed that the identifiable obstacles were attributable to the effects on readability of the complexity of Arabic language grammar. All previous studies involving Arabic text cloze tests had relied on the white spaces method of deletion, as did the larger study reported in Chapter 7, and so this method was regarded as valid. However, the recognition of clitic and base as separable (as in the pilot study reported in Chapter 6) is probably preferable for a fuller account of Arabic grammar. Much deeper psycholinguistic research would be needed to establish to what extent clitics and base words are processed separately by mother-tongue readers and hearers of Arabic. Hence the choice between these two cloze deletion methods can still be seen as an open question, on which this study is the first to gather comparable data.

A further limitation can be observed in the qualitative part of the study. The results from the interviews showed differences between the two groups of teachers: the more-experienced, and those with less experience. Despite every effort having been made by the researcher to explain to the teachers in detail that their answers would be held in the strictest confidence during the interview and be anonymous in the research, the less experienced teachers’ self-reported information reveals possible bias due to feelings of insecurity associated with inexperience. This might in turn have shaped their answers with regard to their more positive opinions of the new science textbook (Stone, Bachrach, Jobe, Kurtzman, & Cain, 1999). This calls for further research.
The validity of the student questionnaire might be open to question as it involved self-reporting. Results from the question about ease of extracting information through reading the Physics textbook (Q3 on the curriculum scale) indicated that the majority of students reported agreement in this scale. But in contrast, their results in the cloze test (Chapter 7) showed high levels of reading difficulty.

It was originally intended that the cloze test passage would not have been previously encountered by the target students. The passage should have been new to them as this is one of the major concepts of using the cloze procedure. Due to the time constraints in collecting the data between the two cities, Jeddah and Abha, and travelling between three schools in each city, the lesson had already been delivered to one class before the data gathering. Although this was a limitation of this particular investigation, valuable results emerged nonetheless. It was found that there was no difference in the results between the latter class and the other classes who had no prior knowledge of this lesson. This limitation provided the study with further and even more interesting details about the difficulty of accessing the textbook even when the lesson had been previously explained.

10.7 Implications for practice

This section outlines the practical implications of the findings from this study for science education in Saudi Arabia, and in other countries where Arabic is the medium of instruction. Implications for future research, and for education policy, will be presented in the two final sections.
10.7.1 Fostering Saudi learners’ scientific literacy

A central purpose of this study was to identify the characteristics of the language of the mandatory Saudi Year 10 Physics textbook and the impact these might have on learners’ understanding. The research first explored the differences in style of written language used in different school subject textbooks, based on expert teachers’ judgements of textbook readability levels. The Physics passage was rated as the hardest passage for Year 10 students to read. This points to a need for educators to pay more attention to subject-specific writing styles in instructional materials, for the purposes of evaluating their suitability, designing more effective materials, and designing educational practices to develop learners’ ability to extract meaning from their subject-specific texts.

While this research did not aim to produce a readability formula, it is noteworthy that the application of the two available formulas used in the Physics passage produced inconsistent results. Overall, the expert ranking of textbook passages indicated that the science passages (Physics and Biology) are more difficult for learners to read than passages from other subject areas. This suggests that scientific language is likely to pose challenges for learners in any science subject. This study has identified specific types of language difficulties which occur in the Physics textbook. Although there are various types of difficulties in terms of the language features, close investigation of these in Chapters 6 and 7 has shown what might be problematic for students when they are reading.

Accessing any subject is based on reading ability. Improving reading skills is achieved through a process that is built through all the learning stages. In early 2018, the Saudi National Centre of Assessment launched a new series of national assessments which
include a national assessment for science, mathematics and reading in the Arabic language. The first trial of the assessments was in 196 schools in Riyadh, Jeddah, Makkah and Dammam and involved 16,000 students (girls and boys). The results of the present study suggest that Arabic use within discipline areas could be a useful focus for the test as it develops, and that classroom attention to the specific issues they raise could improve student reading performance in general.

Another issue that might affect reading ability is the orthographic representation of vowels in the textbook. Although this research has not gathered specific data on this issue, a substantial recent study by Hussien (2014) found that including the Arabic vowel diacritics in the Year 10 school language textbook improved reading comprehension.

A further language issue that is described in this study is the use of English terms and symbols within the Arabic text, in effect presenting learners with foreign language material as well as Physics material. Earlier research found that Saudi students are willing to learn English as a subject (Al-Swuail, 2015). However, including English in Physics textbooks raises the level of difficulty in accessing the already challenging Physics subject matter. This study’s findings related to problematic language features point to issues that undoubtedly affect student learning ability and challenges that they encounter.

10.7.2 What do teachers need to do?

The findings from teacher interviews showed conflicting views between the two groups of teachers interviewed. The more experienced teachers seemed to be more aware of their students’ difficulties in accessing the reading materials. The less experienced teachers seemed to align with the new student-centered pedagogy in terms of leaving students to
read the Physics textbook without their help. In this matter, the findings of this study suggest that science teachers need to be alerted to the fact that the ability to read is a necessary component for understanding scientific concepts. Science teachers should continually develop their students’ capability in all aspects of learning to ensure that they develop the skills to analyse, interpret, read and express their own understanding of the science concepts.

Skills such as critical thinking, arguing and ability to analyse, should be basic components in pre-service teacher training in Saudi Arabia (Al-Ghamdi, 2013). Building these trainees’ confidence in this style of learning and teaching will positively influence their entire teaching career. Qualified science teachers can work with students’ interests in their subject to enhance the effectiveness of the students’ learning (R. Al-Ghamdi, 2017).

10.7.3 Improving schools’ learning culture

Culture in Saudi Arabia has shaped many aspects of education, as the qualitative results indicate in Chapter 8. The teacher-centred approach in Saudi classes has created a gap between students and teachers (Litvin, 2010). Students are expected to respect the ultimate authority of their teachers in the classroom even to obeying simple instructions such as ‘use your pen’ or ‘highlight this point’ (Al-Mutairi, 2007). Shifting the style of teaching from teacher-centred to student-centred, and curriculum reform focusing more on critical thinking rather than memorising, are significant elements in Saudi education reform. To achieve the goals of these changes will require broader changes in Saudi educational culture as it is practised by teachers and students in classrooms. Students need to be free from the restrictions in the classroom and engage effectively with their teachers. The communicative approach, which increases the opportunity for dialogue between
students and teachers, will have a positive impact on students’ scientific thinking (Al-Hammad, 2015).

Teaching and learning culture needs to be re-aligned with social values (Al-Ghanem, 2009) because successful implementation of any supposed improvements will depend on community acceptance. Reflecting on those elements, Dr. Ahmed Alisa, the Saudi Minister of Education has stated that the relationship between students and teachers should be changed to encourage students toward more critical thinking. He asserted that promoting a culture of dialogue and debate among the students will contribute to the development of their intellectual skills and the skill of persuasion and listening through dialogue, discussion and reading, so that they can complete their educational journey.

10.8 Implications for research

This study has provided evidence regarding the use of the current Physics textbook in Saudi classes and how teachers and learners view the accompanying changes in Saudi educational reform. The study investigated in detail the written language style used in the Year 10 Physics textbook, and the different grammatical elements that might create reading difficulties caused by this style of language. Teacher interviews and student surveys were employed to explore perceptions and opinions toward the new changes. These findings point to some promising directions and matters to be explored in further research.

This sample can be expanded to gain further insight and greater reliability. As mentioned earlier, this study was restricted to female students. The views of male teachers and students towards science courses, and similar cloze testing with male students could
establish a more complete picture. Further studies could explore these issues in other science subjects and other year levels.

Further progress is needed in the ongoing research toward creating a valid readability formula. Such formulas have not been explored sufficiently in educational research on Arabic; nor have their applications in the development of curriculum or measuring the readability of specific textbooks, in comparison to the literature on learning where English is the medium of instruction.

There is a lack of well-developed Arabic programs for testing students with cloze tests. A program such as thinkliteracy, an English language web-based software package (https://app.thinkliteracy.com/info), can enable researchers or educators to examine a selected passage for any potential language difficulties. Such programs can save time, and provide immediate feedback to cloze test givers and test takers. Developing a similar valid Arabic readability analysis program will enhance the research in Arabic language education.

10.9 Policy implications

As noted earlier, the Saudi Ministry of Education has prioritised reform of the current science textbook which is translated and adapted from an American textbook. This reform could be enhanced if the style of language to be used is considered in light of reducing reading difficulty.

Saudi Vision 2030 has challenged all education sectors to work toward fulfilling this new vision for the nation’s future. The present study’s findings have pointed toward ways of
improving teacher skills and the school environment, increasing technology availability, making textbooks more accessible and improving student reading skills, all of which would make a difference to improve the Saudi education system, enabling it to better equip its students for the future. Constructive alignment of all these factors in policy development should be given high priority if this vision is to be achieved.
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Appendices

Appendix A: Statement on Contribution

This thesis, “Science Literacy and Language in High School Physics in Saudi Arabia” incorporates four chapters which comprise the substance of articles published in and submitted to scholarly journals.

The articles are:


We, the authoring team for these articles, attest that Research Higher Degree candidate Nouf Albadi made the major contribution to the preparation of these articles in the areas of conceptual development; literature review; instrument design, production and implementation; data collection and analysis; text production; and publication facilitation.

(Signature of Co-Author)  
AProf John Mitchell O’Toole  
Date: 14 June 2018

(Signature of Co-Author)  
Dr. Jean Harkins  
Date: 14 June 2018

(Signature of Candidate)  
Nouf Albadi  
Date: 14 June 2018

(Signature of ADRT, FEDUA)  
Dr. Sally Hewat  
Date: 20 June 2018
Appendix B: Default spreadsheet format for review of literature in Arabic

**Sheet 1**

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<th>Expert</th>
<th>Compute Text</th>
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<td>2017</td>
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<td>Not Provided</td>
<td>Policy</td>
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Appendix C: Ethics Approval

HUMAN RESEARCH ETHICS COMMITTEE

Notification of Expedited Approval

To Chief Investigator or Project Supervisor: Dr Mitchell O’Toole
Cc Co-investigators / Research Students: Dr Jean Harkins and Mrs Nouf Mohammed S Albadi

Re Protocol: Scientific Literacy in Arabic
Date: 18-Aug-2014
Reference No: H-2014-0163
Date of Initial Approval: 15-Aug-2014

Thank you for your Response to Conditional Approval submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under Expedited review by the Chair/Deputy Chair.

I am pleased to advise that the decision on your submission is Approved effective 15-Aug-2014.

In approving this protocol, the Human Research Ethics Committee (HREC) is of the opinion that the project complies with the provisions contained in the National Statement on Ethical Conduct in Human Research, 2007, and the requirements within this University relating to human research.

Approval will remain valid subject to the submission, and satisfactory assessment, of annual progress reports. If the approval of an External HREC has been "noted" the approval period is as determined by that HREC.

The full Committee will be asked to ratify this decision at its next scheduled meeting. A formal Certificate of Approval will be available upon request. Your approval number is H-2014-0163.

If the research requires the use of an Information Statement, ensure this number is inserted at the relevant point in the Complaints paragraph prior to distribution to potential participants. You may then proceed with the research.

Conditions of Approval

This approval has been granted subject to you complying with the requirements for Monitoring of Progress, Reporting of Adverse Events, and Variations to the Approved Protocol as detailed below.

PLEASE NOTE:
In the case where the HREC has "noted" the approval of an External HREC, progress reports and reports of adverse events are to be submitted to the External HREC only. In the case of Variations to the approved protocol, or a Renewal of approval, you will apply to the External HREC for approval in the first instance and then Register that approval with the University’s HREC.

• Monitoring of Progress
Other than above, the University is obliged to monitor the progress of research projects involving human participants to ensure that they are conducted according to the protocol as approved by the HREC. A progress report is required on an annual basis. Continuation of your HREC approval for this project is conditional upon receipt, and satisfactory assessment, of annual progress reports. You will be advised when a report is due.

- **Reporting of Adverse Events**

1. It is the responsibility of the person first named on this Approval Advice to report adverse events.

2. Adverse events, however minor, must be recorded by the investigator as observed by the investigator or as volunteered by a participant in the research. Full details are to be documented, whether or not the investigator, or his/her deputies, consider the event to be related to the research substance or procedure.

3. Serious or unforeseen adverse events that occur during the research or within six (6) months of completion of the research, must be reported by the person first named on the Approval Advice to the (HREC) by way of the Adverse Event Report form (via RIMS at https://rims.newcastle.edu.au/login.asp) within 72 hours of the occurrence of the event or the investigator receiving advice of the event.

4. Serious adverse events are defined as:
   - Causing death, life threatening or serious disability.
   - Causing or prolonging hospitalisation.
   - Overdoses, cancers, congenital abnormalities, tissue damage, whether or not they are judged to be caused by the investigational agent or procedure.
   - Causing psycho-social and/or financial harm. This covers everything from perceived invasion of privacy, breach of confidentiality, or the diminution of social reputation, to the creation of psychological fears and trauma.
   - Any other event which might affect the continued ethical acceptability of the project.

5. Reports of adverse events must include:
   - Participant’s study identification number;
   - date of birth;
   - date of entry into the study;
   - treatment arm (if applicable);
   - date of event;
   - details of event;
   - the investigator’s opinion as to whether the event is related to the research procedures; and
   - action taken in response to the event.

6. Adverse events which do not fall within the definition of serious or unexpected, including those reported from other sites involved in the research, are to be reported in detail at the time of the annual progress report to the HREC.

- **Variations to approved protocol**
If you wish to change, or deviate from, the approved protocol, you will need to submit an Application for Variation to Approved Human Research (via RIMS at https://rims.newcastle.edu.au/login.asp). Variations may include, but are not limited to, changes or additions to investigators, study design, study population, number of participants, methods of recruitment, or participant information/consent documentation. Variations must be approved by the (HREC) before they are implemented except when Registering an approval of a variation from an external HREC which has been designated the lead HREC, in which case you may proceed as soon as you receive an acknowledgement of your Registration.

Linkage of ethics approval to a new Grant

HREC approvals cannot be assigned to a new grant or award (ie those that were not identified on the application for ethics approval) without confirmation of the approval from the Human Research Ethics Officer on behalf of the HREC.

Best wishes for a successful project.

Professor Allyson Holbrook
Chair, Human Research Ethics Committee

For communications and enquiries:

Human Research Ethics Administration

Research Services
Research Integrity Unit
The Chancellery
The University of Newcastle
Callaghan NSW 2308
T +61 2 492 17894
F +61 2 492 17164
Human-Ethics@newcastle.edu.au

Linked University of Newcastle administered funding:

<table>
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<th>First named investigator</th>
<th>Grant Ref</th>
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Appendix D: Information statement for school principals (English version)

Dr Mitch O'Toole
School of Education
University of Newcastle
Callaghan, NSW 2308
Tel: +61249216647
Fax:+61249216987
E-mail: mitch.otoole@newcastle.edu.au

Information Statement for the Principals:

*Scientific literacy in Arabic*

Document Version:[1] dated 11/03/2014

You are invited to permit your school to participate in the research project identified above which is being conducted by Mrs Nouf Mohammed Albadi, a PhD student in Education at the University of Newcastle and supervised by Dr. Mitch O'Toole (Principal Supervisor) from the School of Education.

**Why is the research being done?**

The aim of this research is to investigate the existence and any impact of a specialist form of Arabic that may characterise Saudi secondary school Physics classes. Physics textbooks and popular reading appropriate to study participants will be analysed to identify any such specialist style. The participants will be teachers and Year 10 students from six schools in two cities in Saudi Arabia. Teacher participants will be interviewed and students will be asked to complete a survey and a test. Document analysis will suggest language features whose impact will be investigated.

**Who can participate in the research?**

The study will take place in two cities. Three schools will be recruited in each city (6 schools in total).

One teacher from each school will participate (6 teachers in all). There are 35 students in each class, so 420 students are expected to participate. This yields an estimate of 426 participants in all.

The use of two cities should provide dialect variation, the use of three schools in each should provide teacher variation, two classes in each should reduce idiosyncratic effects and the total number of students should be sufficient to allow quantitative analysis.

Cultural factors require that the female researcher operate in girls’ schools.

**What choice do you have?**

Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the project. Whether or not you decide to participate, this decision will not disadvantage you. If you choose to participate, you will be acknowledged for your contribution in reports of the research, unless you say that you want to remain anonymous. You can stop participating at any time without giving a reason, and withdraw any data that could identify you.

**What would teacher and student participants be asked to do?**

If you agree to permit them to participate, students are asked to respond freely and honestly to a number of statements which will try to investigate their attitude toward different aspect in relation to their Physics course you will be required to respond to a questionnaire survey that contains the statement and complete a cloze text test to assess their readability level. The questionnaire and test will both be provided in Arabic.
Participating teachers will be asked to respond freely and honestly to a number of statements open-ended questions which will designed to enable the researcher to extract relevant information. Most of the questions are about the textbook and how teachers deal with it.

**How much time will it take?**

Each interview for teachers will take between 20-30 minutes. The questionnaires for students should take no longer than 30 minutes to complete and the cloze text test should take no longer than 45 minutes.

**What are the risks and benefits of participating?**

We cannot promise you or your child any direct benefit from participating in this research but you will be contributing to research that may help to improve the language uses in Physics textbook. This project will not involve any potential risks, physical or psychosocial harm for participants.

**How will your privacy be protected?**

Participants can choose whether or not to be acknowledged by name as a contributor to the research. Personal data collected during the research will be kept securely and only accessed by the researcher, and will be stored for at least 5 years at the University of Newcastle.

**How will the information collected be used?**

The results will be reported in research project reports thesis, and may be presented at conferences and in professional journals. The questionnaires survey, interview, cloze test, will be safely kept in a secure store at the University of Newcastle, and may be used for research or educational purposes unless you say that access to them should be restricted. Individual participants or organisations will be acknowledged in any reports arising from the project, unless they have said they wish to remain anonymous. If you wish to receive a summary of the findings, you can give an address to the researcher for this to be sent to you within one year after completion of the study.

**What do you need to do to participate?**

Please read this Information Statement and be sure you understand its contents before you consent to participate. If there is anything you do not understand, or you have questions, contact the researcher. If you would like to participate, please complete the attached Consent Form and return it to the researcher. Please forward this invitation to any other School Principals who may be interested in having members their school participate in the research.

**Further information**

If you would like further information please contact Dr Mitch O'Toole, whose address is shown above, or Mrs Nouf Mohammad Albadi, Nouf.Albadi@uon.edu.au, +61402644478.

Thank you for considering this invitation.

Your participation would be greatly valued.
Appendix E: Information statement for school principals (Arabic version)

Dr Mitch O'Toole
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Faculty of Education and Arts
University of Newcastle
Callaghan, NSW 2308
Tel: +61249216647
Fax:+61249216987
E-mail: mitch.otoole@newcastle.edu.au

ورقة المعلومات لمدير المدرسة

أنت مدعو للمشاركة في هذا المشروع الذي تجريه الباحثة توف محمد الابدي طالبة الدراسات العليا بجامعة نيوكنسل الاسترالية و تحت إشراف الدكتور متش أوتو الإقراض في كلية التربيةاء والأداب بجامعة نيوكنسل.

ما هو الدواعي لإجراء هذا البحث:

الغرض من هذا البحث دراسة تأثير أي شكل متخصص في اللغة العربية قد يساعد في تشكيل النموذج الأفضل لتدريب الفيزياء في المدارس الثانوية السعودية. كما ستتولى الكتب الدراسية لمادة الفيزياء و الكتب المشهورة التي تناسب المشاركين لتحديد الأسلاك اللغوية المتخصص للمسؤولين للمشاركين. المشاركين في هذه الدراسة هم معلموات مادة الفيزياء إضافة إلى طالبات الصف الأول الثانوي في ثمان مدارس ثانوية في مدينتين سعوديين. ستقتصر مشاركة المعلموات على الإجابة في جو أخوي على عدد من الأسئلة في شكل مقابلة شخصية فيما تستعمل طالبات الاستبيان و الامتحان المعدان للدراسة. و ستظهر نتيجة التحليل الواسع اللغوي الأكثر ملاءمة للدراسة.

من هو الشخص الذي يمكنه المشاركة في مشروع البحث?

سيتم إجراء هذه الدراسة في مدينتين سعوديين بعجل ثلاث مدارس لكل مدينة بمجموع ست مدارس. كما سيشارك في الدراسة معلمة واحدة من كل مدرسة بمجموع ست معلمات، كما سيتم تطبيق الملاحظات المباشرة من فصيل الفيزياء لكل مدرسة بمجموع أربع عشر فصلا. يتوقع أن يكون عدد طالبات الفصل الواحد 35 طالبة بما مجموعه 420 طالبة مشاركة ليكون مجموع المشاركين النهائي من معلمات و طالبات 426 مشاركة.

من المتوقع أن يوفر إجراء الدراسة في مدينتين من منطقتين مختلفتين نوعيةً نوعيةً من حيث الهيكل فيما يوفر إجراء الدراسة في ثلاث مدارس لكل مدينة نوعاً في المعلمات المشاركين.

تتماشى هذه الدراسة مع الأخلاقيات الدينية والثقافية للمجتمع السعودي بان يقتصر تطبيق هذه الدراسة في مدارس البنات.

ما هي خيارك؟
المشاركة في هذه الدراسة حقك الشخصي، وستقتصر المشاركة على الأشخاص الذين يعملون موافقتهم على المشاركة في هذه الدراسة.

فيما وافق أو رفضت المشاركة في هذه الدراسة، فإن قرارك لن يؤثر عليك. إذا ما قررت المشاركة، فإنه يحق لك الانسحاب من مشروع البحث في أي وقت دون إبداء أسبابك، كما أن ذلك الحق في ترك أي بيانات قد تكشف شخصيتكنك.

ماذا سيطلب منك في حال وافقت على المشاركة؟

إذا ما وافقت على المشاركة فإنه يرجى منك الإجابة بصراحة مطلقة على عدد من الرباطات التي تعين الباحث على الحصول على معلومات أكثر عن موضوع الدراسة:

- الإجابة على الاستبيان الخاص للطيع طلابي حذاء فيزياء.
- المشاركة الطلابية في اختبار الككلز تأتي لقياس مستوى الإقراض.

مشاركة المعلومات للإجابة على الاستمارة في البحث متعلق بالمنهج الدراسي وطريقة تعاطي المعلومات معه.

كم سيستغرق ذلك؟

في حالة وافتك على المشاركة فإن المقابلة الشخصية تتم بين 20-30 دقيقة. أما اجابة الطالبات على الاستبيان يستغرق 30 دقيقة واجابة الطالبات على اختبار الككلز تأتي لقياس مستوى الإقراض.

ما هي المخاطر والمنافع التي ستستوعدها على المشاركة؟

لا تتألف المشاركة في هذا المشروع أي نوع من العوائد المالية أو غيرها للمشارك. ونوضح للآخرين المشاركات في هذا البحث أن مشاركتك تعد مساهمة في إنجاح مشروع البحث، ويستulta إلى الأهداف المشتركة منه، وهذا بدوره قد يؤثر إيجابا في تطوير الابتكار اللغوي المستخدم في اعداد كتابة فيزياء.

كيف ستتم المحافظة على خصوصيتكم؟

يحظى المشاركة الاختيار في ذكرها بالاسم في البحث من عمه. كما أن البيانات الشخصية التي ستتم جمعها لن تكون محدودا أي شخص آخر الوصل لها عدد الباحث ومسيرته. وطبقا لوالد التحذيرية لجامعة نيوكاسال فإن البيانات التي يتم جمعها ستحفظ في مكان امن لمدة خمس سنوات من تاريخ اكتمال الدراسة.

كيف سيتم استخدام البيانات التي تم جمعها؟

ستستخدم البيانات التي تم جمعها خلال هذه الدراسة للأغراض أكاديمية في الرسالة العلمية التي ستقدمها الباحثة لجامعة نيوكاسال الأسترالية. كما أن نتائج الدراسة أو جزء منها قد تنشر في مجلات علمية أو تقدم في مؤتمرات ذات علاقة. كما أن مواد الدراسة من استبيانات و
مقابلات شخصية و اجتماعات سيتم حفظها في جامعة نيوكاسل وقد تستخدم لأغراض بحثية أو تعليمية أخرى إلا إذا طالبتم باختصار المشاركة على هذا البحث فقط. كما نوضح بناءً على منهج التدريس الممارسات المشتركة في هذا البحث بنتائج البحث إلا عند مطالبتكم بحجب هويتهما. وفي حال رغبكم الحصول على ملخص نتائج هذه الدراسة، فرجو منك التكلم بتزويدي بوسائل التواصل معلق لتزويدك بمملخص النتائج خلال عام من انتهاء الدراسة.

ما الذي يتوجب عليك عمله للمشاركة؟

نرجو منك التكلم بقراءة هذا الدليل و التأكد من فهمك لجميع أجزاءه قبل إعطاء موافقتكم على المشاركة. وما إذا ما واجهتك صعوبة في فهم أي جزء من هذا الدليل أو كان لديك أي استفسار، نرجو منك عدم التردد في سؤال الباحثة. وفي حال رغبتكم في المشاركة، نرجو منك التكلم واستكمال نموذج الموافقة على المشاركة المرفق و اعادته للباحثة.

إذا رغبت في الحصول على معلومات أخرى الرجاء الاتصال ب: 

المشرف الدراسى: الدكتور متش أتوول

الباحثة: نوف محمد البادي

كلية التربية جامعة نيوكاسل

هاتف: 40264447861

فاكس: 61249216987

noufalbadi@gmail.com

mitch.otoole@newcastle.edu.au

+61249216647

+61249216987

+61249216647

+61249216987

0554693680
Appendix F: Consent form for school principals (English version)

Dr Mitch O'Toole  
School of Education  
Faculty of Education and Arts  
University of Newcastle  
Callaghan, NSW 2308  
Tel: +61 2 4921 6647  
Fax:+61 249216987  
E-mail: mitch.otoole@newcastle.edu.au

Consent Form for the School Principal:

Scientific literacy in Arabic


I agree that students and teachers in my School can participate in the above research project and give my consent freely.

I understand that

• the project will be conducted as described in the Information Statement, a copy of which I have retained
• participants can withdraw from the project at any time and do not have to give any reason for withdrawing
• participants can stop talking with the researcher at any time, or choose not to answer any question(s)
• Participants' personal information will remain confidential to the researchers.

I consent to

• distribute the project information to students and teachers in my School

  ☐Yes ☐No

• give permission to conduct research on the premises, and during activates classes.

  ☐Yes ☐No

I have had the opportunity to have questions answered to my satisfaction.

Print Name: ________________________________ Position_________________________

Signature: ________________________________ Date:_________________________

I ask for a summary of the research findings to be sent to me: ☐ Yes ☐ No

If yes, please give email and/or postal address:

Email: __________________________________________

Post:  __________________________________________

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Appendix G: Consent form for school principal (Arabic version)

Consent Form for the School Principal

إقرار بالموافقة على المشاركة في مشروع البحث

أقر بما قدمت من معلومات حول مشروع البحث الموضح عنوانه عالياً وقد أعطيت موافقتى بحرية مطلقة.

و أنا على علم بأن:

- المشروع سوف يجري بالطريقة الموضحة في دليل معلومات مشروع البحث التي أطلعت عليها.
- استغلال المشاركين السري لمشروع البحث في أي وقت، دون إبداء أي مسببات للإنسحاب.
- من حق المشاركين التوقف عن التحديث للباحث في أي وقت، أو عدم الإجابة عن بعض الأسئلة التي لا تتناسب.
- بعد إجراء المشاركون للتسجيلات واعتمادها، سيتم حفظ المواد المسجلة حاسوبياً وحمايتها بكلمة مرور، وستكون من الممكن الاطلاع عليها إلا من قبل الباحث أو أحد مشرفته.
- سوف يتم تحليل المواد المسجلة حاسوبياً وستتم حفظها بكلمة مرور، وستكون من الممكن الاطلاع عليها إلا من قبل الباحث أو أحد مشرفته.
- ستظل كافة معلوماتي الشخصية سرية لدى الباحث.

كما أوافق على:

- توزيع مادة البحث على الطلاب والمدرسين في مدرستي.
- أجراء البحث في المدرسة في أوقات المحصص الرسمية.
- وقد أعطيت موافقتى هذا برغتى ودون أي ضغوط من الباحث.

الوظيفة:
التاريخ:

أرغب في الحصول على ملخص النتائج هذه الدراسة إذا كانت الإجابة بنعم. فضلًا التذكر بكتابة بريدك الإلكتروني أو عنوانك البريدي.

البريد الإلكتروني: noufalbadi@gmail.com
العنوان البريدي: 966554693680

noufalbadi@gmail.com

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Appendix H: Information statement for teachers (English version)

Dr Mitch O’Toole  
School of Education  
Faculty of Education and Arts  
University of Newcastle  
Callaghan, NSW 2308  
Tel: +6124216647  
Fax:+61249216987  
E-mail: mitch.otoole@newcastle.edu.au

Information Statement for Teachers:  

Scientific literacy in Arabic


You are invited to participate in the research project identified above which is being conducted by Mrs Nouf Mohammed Albadi, a PhD student in Education at the university of Newcastle and supervised by Dr. Mitch O’Toole (Principal Supervisor) from the School of Education.

Why is the research being done?

The aim of this research is to investigate the existence and any impact of a specialist form of Arabic that may characterise Saudi secondary school Physics classes. Physics textbooks and popular reading appropriate to study participants will be analysed to identify any such specialist style. The participants will be teachers and Year 10 students from six schools in two cities in Saudi Arabia. Teacher participants will be interviewed and students will be asked to complete a survey and a test. Document analysis will suggest language features whose impact will be investigated.

Who can participate in the research?

The study will take place in two cities. Three schools will be recruited in each city (6 schools in total).

One teacher from each school will participate (6 teachers in all). There are 35 students in each class, so 420 students are expected to participate. This yields an estimate of 426 participants in all.

The use of two cities should provide dialect variation, the use of three schools in each should provide teacher variation, two classes in each should reduce idiosyncratic effects and the total number of students should be sufficient to allow quantitative analysis.

Cultural factors require that the female researcher operate in girls’ schools.

What choice do you have?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the research. Whether or not you decide to participate, this decision will not disadvantage you. If you choose to participate, you will be acknowledged for your contribution in reports of the research, unless you say that you want to remain anonymous. You can stop participating at any time without giving a reason, and withdraw any data that could identify you.

What would you be asked to do?

If you agree to participate, you are asked to respond freely and honestly to a number of statements open-ended questions which will designed to enable the researcher to extract relevant information. Most of the questions are about the textbook and how teachers deal with it.
How much time will it take?

Each interview will take between 20-30 minutes.

What are the risks and benefits of participating?

We cannot promise you any direct benefit from participating in this research but you will be contributing to research that may to improve the language uses in Physics textbook.

How will your privacy be protected?

Participants can choose whether or not to be acknowledged by name as a contributor to the research. Personal data collected during the research will be kept securely and only accessed by the researcher, and will be stored for at least 5 years at the University of Newcastle.

How will the information collected be used?

The results will be reported in research project reports thesis, and may be presented at conferences and in professional journals. The questionnaires survey, interview, close test, will be safely kept in a secure store at the University of Newcastle, and may be used for research or educational purposes unless you say that access to them should be restricted. Individual participants or organisations will be acknowledged in any reports arising from the project, unless they have said they wish to remain anonymous. If you wish to receive a summary of the findings, you can give an address to the researcher for this to be sent to you within one year after completion of the study.

What do you need to do to participate?

Please read this Information Statement and be sure you understand its contents before you consent to participate. If there is anything you do not understand, or you have questions, contact the researcher. If you would like to participate, please complete the attached Consent Form and return it to the researcher.

Further information

If you would like further information please contact Dr Mitch O’Toole, whose address is shown above, or Mrs Nouf Mohammad Albadi, Nouf.Albadi@uon.edu.au, +61402644478.

Thank you for considering this invitation.

Your participation would be greatly valued.

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ورقة المعلومات للمدارس

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أدت مدعو المشاركة في هذا المشروع الذي تجريه الباحثة نوف محمد نموذج الدراسة العليا بجامعة نيوكاسل الاسترالية و تحت إشراف الدكتور ميش أوتوول المحاضر في كلية التربية و الآداب بجامعة نيوكاسل.

ما هي الدواعي لإجراء هذا البحث?

الغرض من هذا البحث دراسة تأثير أي شكل متخصص في اللغة العربية قد يساعد في تشكيل النموذج الأفضل لتدريس الفيزاء في المدارس الثانوية السعودية. كما سيتم تحليل الكتب الدراسية لمادة الفيزاء و الكتب المشهورة التي تناسب المشاركين لتحديد الأسلوب اللغوي المتخصص الأكثر ملاءمة للمشاركين. المشاركون في هذه الدراسة هم معلمان مادة الفيزاء أضافًا إلى طلاب الصف الأول الثانوي في ثمان مدارس ثانوية في مدينتين سعوديين. ستتقاضى مشاركة المعلم على الإجابة في جو أخوي على عدد من الاستمارات في شكل مقابلة شخصية فيما تستكمل الطالبات الاستبان و الامتحان المدارسة للدراسة. و تظهر نتائج التحليل الوسائط اللغوية الأكثر ملاءمة للدراسة.

من هو الشخص الذي يمكنه المشاركة في مشروع البحث؟

سيتم إجراه هذه الدراسة في مدينتين سعوديين بعدد ثلاث مدارس لكل مدينة بمجموع ست مدارس. كما سيشارك في الدراسة معلمة واحدة من كل مدرسة بمجموع ست معلمات. يتوقع أن يكون عدد طالبات الفصل الواحد 35 طالبة بما مجموعه 420 طالبة مشاركة ليكون مجموع المشاركين النهائي من معلمات و طالبات 426 مشاركة.

من المتوقع أن يوفر إجراء الدراسة في مدينتين من مناطق مختلفة و تتبعا لغوية من حيث اللهجات فيما يوفر إجراء الدراسة في ثلاث مدارس لكل مدينة بنوعا في المعلومات المشاركات.

تتناول هذه الدراسة مع الاختلافات الدينية و الثقافية للمجتمع السعودي و أن يقتصر تطبيق هذه الدراسة في مدارس الاطفال.

ما هي خيارنا؟
المشاركة في هذه الدراسة حقك الشخصي وستقتصر المشاركة على الأشخاص الذين يعطون موافقتهم على المشاركة في هذه الدراسة. فيما وافقت أو رفضت المشاركة في هذه الدراسة، فإن قرارك لن يؤثر عليك. إذا ما قررت المشاركة، فإنه يحق لك الانسحاب من مشروع البحث في أي وقت دون إبداء أسبابك، كما أنك الحق في ترك أي بيانات قد تكشف شخصيتكم.

ماذا سيطلب منك في حال وافقتك على المشاركة؟

إذا ما وافقتك على المشاركة فإنه يرجى منك الإجابة بصراحة مطلقة على عدد من العبارات التي تعلق بالبحث على الحصول على معلومات أكثر عن موضوع الدراسة. أكثر الامكانيات الواردة في البحث تتعلق بالمنهج الدراسي وطريقة تعاطي المعلومات معه.

كم سينتغر منك ذلك؟

في حال موافقتك على المشاركة فإن المقابلة الشخصية تمتد بين 20-30 دقيقة.

ما هي المخاطر والنتائج التي ستكون على المشاركة؟

لا تتضمن المشاركة في هذا المشروع أي نوع من العوائد المالية أو غيرها للمشارك. وتوضيح للأبحاث المشاركات في هذا البحث أن مشاركاتك تعد مساهمة في إنجاح مشروع البحث والوصول إلى الأهداف المشتركة منه، وهذا بدوره قد يؤثر إيجابا في تسريع الابتكارات اللغوية المستخدمة في إعداد كتب مادة الفيزياء.

كيف سنتظم المحافظة على خصوصيتك؟

تتم المحافظة على خصوصيتك بحث للمشاركة الاختياري في ذكرها بالاسم في البحث من عمه. كما أن البيانات الشخصية التي ستتم جمعها لن تكون متضمنة في أي شخص آخر الوصول لها عند البحث ومشاركته. وطبقا للوائح التنظيمية لجامعة نيوكاسل فإن البيانات التي يتم جمعها ستحفظ في مكان آمن لمدة خمس سنوات من تاريخ إكمال الدراسة.

كيف سيستخدم البيانات التي تم جمعها؟

تستخدم البيانات التي تم جمعها خلال هذه الدراسة لأغراض أكاديمية في الرسالة العلمية التي ستقدمها الباحثة لجامعة نيوكاسل الاسترالية. كما أن نتائج الدراسة أو جزء منها قد نشر في مجلات علمية أو تقدم في مؤتمرات ذات علاقة. كما أن مواد الدراسة من استنادات ومقابلات شخصية وامتحانات سيتم حفظها في جامعة نيوكاسل وقد ستستخدم لأغراض بحثية أو تعليمية أخرى إذا طالبتم بذلك.

المشاركة على هذا البحث فقط. كما نوضح بأننا سنرصد الأفكار أو المنظمات المشاركة في هذا البحث بناءً على البحث إذا أخذت البيانات بحجة هويتهم. و في حال رغبتك الحصول على ملخص لنتائج هذه الدراسة، فرجوا منك التذكر بتوثيدا بوسائل التواصل معك لتزويدك بملخص النتائج خلال عام من انتهاء الدراسة.
ما الذي يتوجب عليك عمله للمشاركة؟

نرجو منك التكرم بقراءة هذا النص وألا تتأمر من فهمك لجميع أجزاءه قبل إعطاء موافقتك على المشاركة. وإذا ما واجهتك صعوبة في فهم أي جزء منه، نرجو منك عدم التردد في سؤال الباحثة. وفي حالة رغبتك في المشاركة، نرجو منك التكرم باستكمال نموذج الموافقة على المشاركة المرفق واعادته للباحثة.

إذا رغبت في الحصول على معلومات أخرى الرجاء الاتصال بـ:

الباحثة: نوف محمد البادي
المشرف الدراسي: الدكتور منش اوتول

كلية التربية جامعة نيوكاسل

هاتف: +61249216647
فاكس: +61249216987

mithch.otoole@newcastle.edu.au
noufalbadi@gmail.com

هاتف: +40264447861
فاكس: +6124921693680

0554693680
noufalbadi@gmail.com
Appendix J: Consent form for teachers and students (English version)

Dr Mitch O’Toole
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Faculty of Education and Arts
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Callaghan, NSW 230
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Consent Form for participating the Research Project:

Scientific literacy in Arabic

Document Version [1]; dated [11/03/2014]

I agree to participate in the above research project and give my consent freely

I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained

I understand that

- the project will be conducted as described in the Information Statement, a copy of which I have retained
- I can withdraw from the project at any time and do not have to give any reason for withdrawing
- My personal information will remain confidential to the researchers.

I consent to

- completing a structured questionnaire □ Yes □ No
- doing a cloze text test □ Yes □ No
- having the interview being audio-recorded □ Yes □ No
- being acknowledged by name in reports of the research □ Yes □ No
- being quoted anonymously in reports of the research □ Yes □ No

I have had the opportunity to have questions answered to my satisfaction.

Print Name: __________________________________________

Signature: __________________________________________

Date: ______________________________________
I ask for a summary of the research findings to be sent to me: □ Yes □ No

If yes, please give email and/or postal address:

Email: __________________________________________

Post: ____________________________________________

Contact Details:

Email: ............................................................

Phone: ............................................................
Appendix K: Consent form for school participating (Arabic version)

Dr Mitch O'Toole
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Faculty of Education and Arts
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Callaghan, NSW 2308
Tel: +61 2 4921 6647
Fax:+61 249216987
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Consent Form for participating the Research Project:

إقرار بموافقة على المشاركة في مشروع البحث

أقر بموافقة على المشاركة في مشروع البحث الموضوع عنوانه عاليه وقد أعطيت موافقتى بحرية مطلقة.

و أنا على علم بأن:

- المشروع سوف يجري بالطريقة الموضوعة في دليل معلومات مشروع البحث التي اطلعت عليها.
- مشاركتى في الانسحاب من المشاركة في أي وقت أراه دون إبداء أي سبب للانسحاب.
- س投资人 كافة معلوماتي الشخصية سرية لدى الباحث.

كما اوافق على:

- استكمال الاستبيان المعتمد للدراسة
- إجراء الامتحان المخصص للدراسة
- المشاركة في المقابلة الشخصية والموافقة على تسجيلها
- ذكر اسمى الأول في نتائج البحث
- الاختبار من كلامي في نتائج البحث

و قد أعطيت موافقتى هذه برغبتي و دون أي ضغوط من الباحث.

الاسم: ____________________________
التاريخ: ___________________________

أرغب في الحصول على ملخص النتائج هذه الدراسة

إذا كانت الإجابة نعم. فلأنا التكريم بكتابة البريد الإلكتروني أو عنوان البريدي

البريد الإلكتروني: ____________________________
العنوان البريدي: ____________________________

وسائل التواصل مع المشاركة: البريد الإلكتروني: noufalbadi@gmail.com
الهاتف: +966554693680

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Appendix L: Information statement for parents and students (English version)

Dr Mitch O'Toole  
School of Education  
Faculty of Education and Arts  
University of Newcastle  
Callaghan, NSW 2308  
Tel: +61249216647  
Fax:+61249216987  
E-mail: mitch.otoole@newcastle.edu.au

Information Statement for the Parents:

Scientific literacy in Arabic


You are invited to permit your child to participate in the research project identified above which is being conducted by Mrs Nouf Mohammed Albadi, a PhD student in Education at the University of Newcastle and supervised by Dr. Mitch O'Toole (Principal Supervisor) from the School of Education.

Why is the research being done?

The aim of this research is to investigate the existence and any impact of a specialist form of Arabic that may characterise Saudi secondary school Physics classes. Physics textbooks and popular reading appropriate to study participants will be analysed to identify any such specialist style.

Who can participate in the research?

The study will take place in two cities. Three schools will be recruited in each city (6 schools in total).

One teacher from each school will participate (6 teachers in all). There are 35 students in each class, so 420 students are expected to participate. This yields an estimate of 426 participants in all.

The use of two cities should provide dialect variation, the use of three schools in each should provide teacher variation, two classes in each should reduce idiosyncratic effects and the total number of students should be sufficient to allow quantitative analysis.

Cultural factors require that the female researcher operate in girls’ schools.

What choice do you have?

Participation in this research is entirely your and your child's choice. Only children whose parents give their informed consent will be included in the research. Whether or not you allow your child to participate, this decision will not disadvantage your child. If you do allow your child to participate, your child will be acknowledged for their contribution in reports of the research, unless you wish your child to remain anonymous. Your child can stop participating at any time without giving a reason, and withdraw any data that could identify her.

What would your child be asked to do?

If you do give permission for your child to participate, she will be asked to respond freely and honestly to a number of statements which will try to investigate their attitude toward different aspects in relation to their Physics course and be asked to participate in a cloze text test to assess the readability of their Physics text. The questionnaire and test will both be provided in Arabic.
How much time will it take?

The questionnaires should take no longer than 30 minutes to complete and the cloze text test should take no longer than 45 minutes.

What are the risks and benefits of participating?

We cannot promise you or your child any direct benefit from participating in this research but you will be contributing to research that may help to improve the language uses in Physics textbook.

How will your child’s privacy be protected?

Participants can choose whether or not to be acknowledged by name as a contributor to the research. Personal data collected during the research will be kept securely and only accessed by the researcher and his supervisors, and will be stored for at least 5 years at the University of Newcastle.

How will the information collected be used?

The results will be reported in research project reports, thesis, and may be presented at conferences and in professional journals. The questionnaires survey, interview, close test will be safely kept in a secure store at the University of Newcastle, and may be used for research or educational purposes unless you say that access to them should be restricted. Individual participants or organisations will be acknowledged in any reports arising from the project, unless they have said they wish to remain anonymous. If you wish to receive a summary of the findings, you can give an address to the researcher for this to be sent to you within one year after completion of the study.

What do you need to do to participate?

Please read this Information Statement and be sure you understand its contents before you give the permission for your child consent to participate. If there is anything you do not understand, or you have questions, contact the researcher. If you would like to give the permission for your child to participate, please complete the attached Consent Form and return it to the researcher.

Further information

If you would like further information please contact Dr Mitch O’Toole, whose address is shown above, or Mrs Nouf Mohammad Albadi, Nouf.Albadi@uon.edu.au, +61402644478.

Thank you for considering this invitation.

Your participation would be greatly valued.

Dr Mitch O’Toole Research Supervisor School of Education University of Newcastle Tel: +61249216647 Fax: +61249216987 E-mail: mitch.otoole@newcastle.edu.au

Mr Nouf Albadi Student Researcher School Education University of Newcastle Tel: +61 - 402644478 E-mail: Nouf.Albadi@uon.edu.au
Appendix M: Information statement for parents and students (Arabic version)

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ورقة المعلومات للوالدين

أتمد مدعو للمشاركة في هذا المشروع الذي تجري الباحثة نور محمد البادي طالبة الدراسات العليا بجامعة نيوكاسل الاسترالية و تحت إشراف الدكتور
منش أوتو المحاضر في كلية التربية والآداب بجامعة نيوكاسل.

ما هي الدواعي لإجراء هذا البحث:

الغرض من هذا البحث دراسة تأثير أي شكل مخصص في اللغة العربية في المدارس الثانوية للمواج. كما سيتم تحليل الكتب الدراسية لمادة الفيزياء والكتب المشهورة التي تناسب المشاركون للتحديد الأسلوب اللغوي المخصص الأكثر ملاءمة للمشاركون. المشاركون في هذه الدراستة هم معلمو مادة الفيزياء إضافة إلى طالبات الصف الأول الثانوي في ثمان مدارس ثانوية في مدينتين سعوديتين. ستستغرق مشاركة المعلمين على ألاجية فيجو أؤري على عدد من الاستمارات في شكل مقابلة شخصية فيما تشكلند الطالبات الاستبيانات والامتحان المعاين للدراسة. و سيظهر النتائج التحليل الوسائل اللغوية الأكثر ملاءمة للدراسة.

ما هو الشخص الذي يمكنه المشاركة في مشروع البحث?

سيتم إجراء هذه الدراسة في مدينتين سعوديتين بمعدل ثلاث مدارس لكل مدينة بمجموع ست مدارس. كما سيشارك في الدراسة معلمة واحدة من كل مدرسة بمجموع ست طالبات. يتوقع أن يكون عدد طالبات الفصل الواحد 35 طالبة بما مجموعه 420 طالب مشارك مجموع المشاركين النهائي من معلمات وطلاب 426 مشترك.

من المتوقع أن يجبر اجراء الدراسة في مدينتين من منطقتين مختلفتين توسع اثاث من حيث اللهجات فيما يوفر اجراء الدراسة في ثلاث مدارس لكل مدينة توسع في المعلمات المشاركات.

تتماشى هذه الدراسة مع الاختلافات الدينية والثقافية للمجتمع السعودي بناءً على تطبيق هذه الدراسة في مدارس البنات.

ما هي خياراتكم؟
المشاركة في هذه الدراسة حقك الشخصي وستقتصر المشاركة على الأشخاص الذين يعطون موافقتهم على المشاركة في هذه الدراسة. فيما وافق أو رفضت المشاركة في هذه الدراسة، فإن قرارك لن يؤثر عليك. إذا ما قررت المشاركة، فإنه بحقك الانسحاب من مشروع البحث في أي وقت دون إبداء أسبابك، كما أن ذلك الحق في ترك أي بيانات قد تكشف شخصيتك.

ماذا سيطلب منك في حال وافق على المشاركة؟

إذا ما وافقت على المشاركة فإنه يرجى منك الإجابة بصراحة مطلقة على عدد من العبارات التي تبين الباحث على الحصول على معلومات أكثر عن موضوع الدراسة:

- الإجابة على الاستبيان حول تأثير الطابع والتطبيق فيما يتعلق بمادة الفيزياء.

- المشاركة في الإجابة على اختبار الكلوز تبست قياسك عن مستوى الانفتاح.

- ...

كم ستغرق ذلك؟

في حال وافقتم على المشاركة فإن الإجابة على الاستبيان يستغرق حوالي ثلاثون دقيقة واختبار الكلوز تبست يستغرق حوالي 45 دقيقة.

ما هي المخاطر والمنافع التي سكود على المشاركة؟

لا تتضمن المشاركة في هذا المشروع أي نوع من العوائد المالية أو غيرها للمشارك. ونوضح للألواح المشاركات في هذا البحث أن مشاركتكم تعلم مساهمة في إنجاز مشروع البحث والوصول إلى الأهداف المشروعة منه، وهذا بدوره قد يؤثر إيجابا في تطوير الأسلوب اللغوي المستخدم في اعداد كتاب مادة الفيزياء.

كيف ستتم المحافظة على خصوصيتك؟

يجب للمشارك الاختيار في ذكرها بالأسوأ في البحث عن نفسه. كما أن البيانات الشخصية التي ستم جمعها وان يكون بدور أي شخص آخر الوصول لها عبر البحث ومشارفه. وطبقا للوائح التنظيمية لجامعة نيوكاسل فإن البيانات التي يتم جمعها مستفزة في مكان مامم لمدة خمس سنوات بعد تاريخ إكمال الدراسة.

كيف سيتم استخدام البيانات التي تم جمعها؟

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تستخدم البيانات التي تم جمعها خلال هذه الدراسة لأغراض أكاديمية في الرسالة العلمية التي ستقدمها الباحثة لجامعة نيوكاسل الأسترالية. كما أن نتائج الدراسة أو جزء منها قد تنشر في مؤتمرات ذات علاقة. كما أن مواد الدراسة من استبانات ومقابلات شخصية وامتحانات سيتم حفظها في جامعة نيوكاسل وقد تستخدم لأغراض بحثية أو تعليمية أخرى إذا طالبتم بالمشاركة المبكرة على هذا البحث فقط كما توضّح بانتاً. سنوزر الأفراد أو المنظمات المشاركة في هذا البحث بنتائج البحث إذا عند طلبهم بذلك. و في حال رغبتكم الحصول على ملخص النتائج هذه للدراسة، فنرجو منكم التزويد بوسائل التواصل معاً لتزويدكم بملخص النتائج خلال عام من انتهاء الدراسة.

ما الذي يتوجب عليك عمله للمشاركة؟

نرجو منكم التكرم بقراءة هذا النايل والتأكد من فهمك لجميع أجزاءه قبل إعطاء موافقتك على المشاركة. وإذا ما واجهتك صعوبة في فهم أي جزء من هذا النايل أو كان لديك أي استفسار، نرجو منكم التحكم في سؤال الباحثة. في حال رغبتكم في المشاركة، نرجو منكم التكرم باستكمال نموذج الموافقة على المشاركة المرفق واعادة الباحثة.

إذا رغبت في الحصول على معلومات أخرى الرجاء الاتصال بـ:

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Appendix N: Approval letter from The General Directorate of Education in Abha for all schools
Appendix O: Approval letter from The General Directorate of Education in Jeddah for all schools
الملف العربي السعودية
وزارة التربية والتعليم
(280)
العامة للتربية والتعليم بمحافظة جدة
إدارة التخطيط والتطوير
المراجعات:

النكرة: مدير إدارة التخطيط والتطوير.

بدأ، تشهي مصحة الباحثة/ نيف محمد البدائي، السلام عليكم ورحمة الله وبركاته، وبعد

إشارة إلى شرح معاداة الدير العام للتربية والتعليم بمحافظة جدة في الرقم (دبيون) وتاريخ 1435/12/35، بشأن
تسهيل مهمة الباحثة/ نيف محمد البدائي المتبعة إلى جامعة نيوساكس للسياحة، والله يحفظها بعنوان: "السعيات اللوتي...

الصف الأول الثانوي: "تختلف تهيئة الباحثة على درجة الدكتوراه، وتغلب الباحثة في
تطبيق أدوات البحث والذي يشمل على الآتي:

1- إجراء اختبار (المكتوز) على عينة من طالبات الصف الأول الثانوي.

2- توقيع استمارة على الطلاب بعد حضور الحصص.

وقد يختلف تهيئة الباحثة على درجة الدكتوراه وقد تم الاطلاع على أداء البحث (الاستبانة) وتبين

استفادةها من ضوابط الوزارة لهذا الخصوص.

وللصحة تسهيل مهمة الباحثة بتحريكها من تطبيق أدوات البحث، شابرين ومشاركين تعاونوا بـ.

والسلام عليكم ورحمة الله وبركاته...

خليج من هزاز الولاة
الملحقية العربية السعودية
وزارة التربية والتعليم
المطورة للتربية والتعليم بمحافظة جدة
إدارة التخطيط والتطوير
الدراسات والبحوث

وفقها الله

إلى: مديرية المدرسة الثانوية

سمح: مدير إدارة التخطيط والتطوير.

بيان: تسهيل مهمة الباحثة/ توف محمد البادي.

السلام عليكم ورحمة الله وبركاتكم. وبعد

الإشارة إلى شرح سعادة المدير العام للتربية والتعليم بمحافظة جدة ذي الرقم (يديون) وتاريخ 1435/12/25 هـ بشأن
تسهيل مهمة الباحثة/ توف محمد البادي المبتعثة إلى جامعة نيوسكاليس بستراليا. لا يحبها بنوان" الصوريات اللغوية
لمكتب الفيزياء للصف الأول الثانوي". فستطلب تفعيلها للحصول على درجة الدكتوراه، وترغب الباحثة لـ

تطبيق أداء بحثها والذي يشمل على الآتي:

1- إجراء اختبار (الخطوات) على عينة من طالبات الصف الأول الثانوي.
2- توزيع اختبار على الطلاب بعد حضور الحصص.

وهذا ي необходимости للحصول على درجة الدكتوراه وقد تم الاطلاع على أداء البحث (الاستبانة) وتبين
خصوصيتي للشروط الوزارة بهذا الخصوص.

تم تشكيل مهمة الباحثة بتمكينها من تطبيق أداة بحثها، شاكرتين ومقررتين تعاونكم
واحتفامكم بالبحث العلمي.

والسلام عليكم ورحمة الله وبركاتكم.

خليل بن فرج ориг
SURVEY

Dear Participant Teachers:

As a part of my research, this is a preliminary analysis of the language in Physics textbooks that Year 10 students are expected to read. The initial step of this investigation is to determine whether Year 10 Physics text is similar or different to other text that students are asked to read. I would like to invite you to participate in this study.

From the viewpoint of a student of Year 10, read these four passages below and rate each one as:

(1) **very easy**, (2) **easy**, (3) **medium**, (4) **hard** or (5) **very hard** to read.

Passage (A): is from a Biology textbook.
Passage (B): is from a Geography textbook.
Passage (C): is from an Arabic grammar textbook.
Passage (D): is from a Physics textbook.

Researcher:
Nouf Albadi

Rating passages

(A): **Background details:**
1- Teaching experience: _____ years
2- At which level are you teaching at the moment?
   1-Primary _____
   2-Intermediate _____
   3-Secondary _____
3- Have you had any experience in teaching Year 10?
   1-Yes _____
   2-No _____

(B): Please rate the four passages from very hard (5) to very easy (1) for a Year 10 student to read:
A: _____
B: _____
C: _____
D: _____
Appendix Q: Biology passage
Appendix S: Arabic Grammar passage

إذا تأملت الكلمات: (الصديقان، الحريمين، الطالبين) الواردة في المجموعة الأولى (أ) رأيت أن كل واحدة منها تندل على اسمين معيينان مفردين: (صديق، حرم، طالب)، غير مركبين تركيبًا مزجيًا نحو: (حضور موت)، ولا إسناديًا نحو: (جاد الحق)، وأن كل مفرد منها يطابق صاحبه في اللفظ والممعنى، وقد زيدت على آخره ألف وونون في حالة الرفع، ويا، ونون في حالتى النصب والجر، وعند زيادة هذين الحرفين استغنينا عن أن نقول: أقبل صديق وصديق، زرت الحرم والحرم، وأعجبت طالب وطالب، أي أنها قد اكتفينا بهذه الزيادة بدلاً من عطف كلمة على نظيرتها المواضعة لها تمام الموافقة في الحروف والحركات. ويسمى هذا الأسم المعرب الذي يدل على الثين أو التين زيادة ألف ونون أو ياء ونون في آخره ويطابق المفرد في اللفظ والممعنى: المشي.

إذا تأملت الكلمات: (الناثن وثنان وثنين وثنينين) الواردة في المجموعة الثانية (ب) وجدت أن كل لفظ منها دل على اسمين ولكن ليس له مفرد من لفظه فهما ملحقيان بالمشي وعبراين بزيادة ألف ونون في الرفع، ويا، ونون في النصب والجر.

إذا تأملت الكلمات: (كلاهما، وكلاهما وكلاهما وكلاهما) الواردة في المجموعة الثالثة (ج) رأيت أن هذه الكلمات لا مفرد لها من لفظها فليست من المشي بل هي ملحقة بحولته مغزباً إعرابه بالألف رفعًا ويامًا نصبًا وجرًا، وذلك بشرط أن يضافان إلى الضمير.

إذا تأملت الكلمات: (كلًا وكلًا) الواردة في المجموعة الرابعة (د) وجدت أن كل واحدة منها قد أضيفت إلى اسم طاهر فلا يمتها الألف في جميع الأحوال رفعًا ونصبًا وجرًا ولعل تعرياً تعريبًا المشي بل أعربنا كلاً الأسم المعصور بحركات مقدرة على الألف من من ظهورها التعدد.
Using Newton’s laws of motion

The space between two objects affects the force and distance. We see the distance between the two forces that cause the motion. Using Newton’s Second Law of Motion:

The acceleration of an object is proportional to the net force acting on the object and inversely proportional to the mass of the object.

$$a = \frac{F}{m}$$

Where:
- $a$ is the acceleration of the object.
- $F$ is the net force acting on the object.
- $m$ is the mass of the object.

This relationship allows us to calculate the acceleration of an object when we know the force and mass. It also allows us to determine the force needed to achieve a certain acceleration with a known mass.
Appendix U: Original text in Arabic

الفيلزياء هو العلم الذي يدرس المادة والمجالات المؤثرة عليها (كالجاذبية)، واستغلال الطاقات المرتبطة بالمادة وحركتها واندرها على تحويل الطاقة إلى أشكالها المختلفة ومن المميزات الأساسية لعلم الفيزياء إنه علم تجريبي، لا يعتمد على الجاذبية النظرية فقط.

قبل حوالي أربعين عام تقريباً، استنتج جاليليو أن جميع الأجسام التي تسقط سقطاً حراً، يكون لها نفس السرعة، وذلك بإساهم تأثير مقاومة الهواء، وأن هذا السارع لا يتآثر بأي من نوع المادة الساقطة أو وزن هذا الجسم أو الإرتفاع الذي سقط منه أو كون الجسم قد أسقط أو قفز. ويرمز إلى سرعة الأجسام الساقطة بالرمز (g)، وتتغير قيمة (g) تغيرات طفيفة في أماكن مختلفة على الأرض والقيمة المتوسطة لها تقريبًا 9.8 m/s².

 فالتسارع الناتج عن الجاذبية الأرضية هو تسارع جسم يسقط سقطاً حراً نتيجة تأثير جاذبية الأرض عليه.

فبعد سقوط صخرة ترتفد سرعتها بمعدل 2m/s كل ثانية، فيمكن اعتبار السارع موجباً أو سالباً على النظام الإحداثي الذي يتم اتخاذه.

فإذا كان النظام يعتبر الاتجاه إلى الأعلى موجباً، فإن السارع الناجم عن الجاذبية الأرضية عندئذ يساوي [g−]. أما إذا اعتبرنا الاتجاه إلى الأأسفل هو الاتجاه الموجب، فإن السارع الناجم عن الجاذبية يساوي [g+].

عند فتحة كرية إلى أعلى بابعتي إن النظام يعتبر الاتجاه إلى أعلى موجباً، فإن الكثرة تتأثر بالسرعة الموجبة، أما السارع فيكون للاسفل أي أن السارع يكون سالباً وهو يساوي [g] m/s². ولأن (أن فقط) السرعة والتسارع في اتجاهين متعاكسين؛ فإن سرعة الكرة تتلاطم.

وإذا لم يطالب الناس عن تسارع جسم ضد أقصى ارتفاع له أثناء تحليفة فإنهم في العادة لا يتاخذون وقفاً كفاية للتخليل الموقف فيكون إجابتهم: أن السارع يساوي صفر. وهذا ليس صحيح بالطبع. حيث أن أقصى ارتفاع توفر سرعة الكرة تساوي صفر. ولكن ما هو الحال لو كان السارع في هذه النقطة يساوي صفر؟ فإن الكرة لن تكسب أي سرعة للاسفل بل ستبقى معلقة بالهواء عند أقصى ارتفاع لها.

ويمكن أن الأجسام المقطوعة إلى الأعلى لا تبقى معلقة؛ فسوف نستنتج: أن تسارع الجسم عند نقطة أقصى ارتفاع لطريقه يجب أن لا يساوي صفر، لأننا إذا كان بارتفاع يجب أن لا يكون لأسفل.
 علم الفيزياء هو العلم الذي يدرس المادة والمجالات المترتبة عليها (كالجاذبية)، واستخراج الطاقات المترتبة بالمادة وحركتها، وقدرته على تحويل الطاقة إلى أشكال مختلفة، ومن المميزات الأساسية لعلم الفيزياء أنه عالم تجريبي، فلا يعتمد على الجانب النظرى فقط.

قبل حوالي أربعمائة (1-4) قرية، استنتج جاليليو أن الأجسام التي تسقط سرعاتها (g) تكون لها نفس الشاشع (-1-3) ذلك بالأساليب كبيرة (-4-5) للهواء، وأن هذا (1-4) لا يثبت بأن (5-7) نوع مادة الجسم الساقط (8-9) وزن هذا الجسم أو (9-10) الذي سقط منه أو (10-11) الجسم قد أسقط أو (11-12) لمسار الشاشع (8-9) الساقط من الزم (g)...

13-11 (تتغير قيمة (g) تغيرات (14-15) في أماكن مختلفة على (15-16) والقيمة المتوسطة لها (16-18).

فالشاشع الناتج عن (17-18) الأرضية هو الشاشع جسم (18-20) سرعات قانوناً حراً نتيجة تأثير (19-20) الأرض عليه.

فعد (20-20) صغرية تزداد سرعتها ب (21-21) (الشاشع موجباً أو سالباً (22-23)) النظام الإعدادي الذي يتم (24-24).

إذا كان النظام (25-25) الإيجابي إلى الأعلى موجباً (26-26) فإن الشاشع الناتج عن (27-27) الأرضية عندن (g)...

(28-28) إذا اعتبرنا الإيجاب إلى (29-29) هو الإيجاب الموجب; ف (29-30) الشاشع الناتج عن الجاذبية (21-31).

إذا قمنا، هوا (32-32) أعلى (على اعتبار أن (33-33) يعتبر الإيجاب إلى (34-34) فإن الكثافة تغير (35-35) سرعه موجبة، أما الشاشع (36-36) يكون للأسطر (7-38) الشاشع يكون سالباً و (38-39) ش镯 (9.8 m/s) (39-39) السرعة. والشاشع في (40-41) متناقص، فإن سرعة...

وعندما يبتلى (42-42) عن الشاشع جسم عند (43-43) ارتفاع له أثناء تحلقة (44-44) إنه في العامة (45-45)

وقد كافياً تحليل (46-46) فتكون إجابتهم: (47-47) الشاشع يساوي صفر. و (48-48) ليس بصريحة (49-49). حيث أن عند أقصى (50-50) تكون سرعة الركيزة سرعة صفر ولكن ما هو الحال لو كان الشاشع في هذه النقطة يساوي صفر؟

ُفإن الكثافة لن تكون أي سرعة للأسطر؛ بل ستبقى معلقة بالهواء عند أقصى ارتفاع لها.

وإذا أن الأجسام المقدوسة إلى الأعلى لا تبقى معلقة، سوف نستنتج، أن الشاشع جسم عند نقطة أقصى ارتفاع بطيئة يجب أن لا يساوي صفر، وأن اتجاهه يجب أن يكون لأسطر.

Appendix V: Cloze test in Arabic
Physics is the science which investigates matter, the fields which influence it, such as gravity, how energy acts on matter to change its motion and shape and how energy can be transferred to its various shapes. One of the significant characteristics of physics is that it is empirical and not theoretical.

Galileo concluded, four hundred years ago, that each free-falling body has the same acceleration. It accelerates at the same rate regardless of the kind of matter the body is made of, the weight of that body, the height from which it was dropped, or whether it was dropped or thrown. Bodies fall towards the earth because of gravity. The acceleration due to gravity (g) is slightly modified by where a body is located on earth and the average value of 9.8 m/s² is often used in calculations.

When dropping a rock accelerating by 9.8 m/s², this acceleration can be considered positive or negative by the parametric system that is chosen. If we choose ‘upwards’ as our positive direction, a falling body has a negative acceleration, because it is moving downwards (-g), whereas if we chose ‘downwards’ as positive, the acceleration would be positive (+g). ‘Up’ is usually ‘positive’, so throwing a ball upwards gives it both positive velocity and acceleration. When the ball reaches its greatest height, it begins to fall and both velocity and acceleration become negative.

People sometimes ask about the acceleration of the ball as it begins to change direction at the top of its flight. They don’t usually take sufficient time to analyse the situation and their answer would be that the acceleration equals zero. This is not true because gravity applies an acceleration of 9.8 m/s² throughout the ball’s flight. When the ball is at the utmost altitude, it is still and its speed is zero. But gravity continues to accelerate the ball at 9.8 m/s² and it begins to fall, picking up speed as it does. Acceleration moves from positive to negative as the direction changes but it remains at 9.8 m/s².
Appendix X: Levels of student difficulty (1) with features of specialist language

<table>
<thead>
<tr>
<th>Group</th>
<th>Noun</th>
<th>Prn</th>
<th>Adj</th>
<th>Verb</th>
<th>Adv</th>
<th>Conj</th>
<th>Prep</th>
<th>Tech</th>
<th>Sm1</th>
<th>Sm2</th>
<th>Sm3</th>
<th>Fml</th>
<th>Err</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabic</td>
<td>44</td>
<td>47</td>
<td>59</td>
<td>55</td>
<td>53</td>
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<td>57</td>
<td>75</td>
<td>47</td>
<td>39</td>
<td>65</td>
<td>41</td>
<td>52</td>
</tr>
<tr>
<td>n=80</td>
<td>SD=</td>
<td>SD=</td>
<td>SD=</td>
<td>SD=</td>
<td>SD=</td>
<td>SD=</td>
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<td>27</td>
<td>=23</td>
<td>48</td>
<td>26</td>
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<tr>
<td>DfRnk (3)</td>
<td>8</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>(Mean = 56%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>40</td>
<td>31</td>
<td>53</td>
<td>31</td>
<td>36</td>
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<td>SD=</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Difficulty**: Mean percentage of clear student error in replacing deletions of the stated category.

Noun; Pronoun; Adjective; Verb; Adverb; Conjunction; Preposition;

Technical word; Semi-technical word, *Type 1*; Semi-technical word with one meaning, *Type 2*; Semi-technical word with two meanings, *Type 3*; Semi-technical word with three possible meanings; Formal word.

*DfRnk*: Difficulty rank: 1 is most difficult.

English results were recalculated from data drawn from O’Toole and O’Toole (2004).
Appendix Y: Student cloze test

Using Newton's laws

To fill in the blanks, insert the following formulas where appropriate:

\[ F_{\text{newton}} = ma \]

\[ F_{\text{opposite}} = F_{\text{total}} - F_{\text{friction}} \]

The forces involved are:

- \( F_{\text{gravity}} \)
- \( F_{\text{normal}} \)
- \( F_{\text{friction}} \)
- \( F_{\text{air resistance}} \)

The equations:

\[ F_{\text{net}} = ma \]

\[ F_{\text{total}} = F_{\text{gravity}} + F_{\text{normal}} - F_{\text{air resistance}} \]

The units:

- \( N \) for force
- \( m \) for mass
- \( m/s^2 \) for acceleration

The experiment setup:

- Place the object on a smooth surface.
- Apply a force to the object.
- Measure the acceleration of the object.

The conclusions:

- Force is directly proportional to mass.
- Acceleration is inversely proportional to mass.
Appendix Z: Cloze text translation

**Using Newton’s Second Law** [1]


This result is correct on earth [24], or any other [25] planet. Because the amount of $g$ [26] differs from one planet to another and [27] so the amount of $g$ on [28] the moon is less than [29] its value on earth. So [30] the weight of astronauts on [31] the moon are much [32] less than on the earth, though [33] their mass doesn’t change.

**Scales** [34] Some household scales have springs on [35] them. When someone stands upon [36] the scale, the spring exerts pressure on him to [37] upwards when he stands there. Because [38] he doesn’t accelerate, the net [39] force equals zero, and [40] this means $F_{sp}$ the spring [41] that pushes him up [42] equals $F_g$ [43] pushing downward [44], as shown in figure [45] 4-7. Furthermore, the reading on the scale [46] is determined using the force that is exerted by [47] the springs. So that which [48] is measured by the domestic scale is weight [49], and to make it easier to convert between mass [50] and weight, it is scaled to read the mass. But if you were on another planet the amount of pressure on the spring would be different, hence the reading would be different; you should bear in mind that the international unit of mass is the kilogram and the international unit for weight is the Newton.

**Note:** The cloze gaps in the English back-translation obviously do not fall precisely on every fifth word as they do in the Arabic, because of the different sentence structure between the two languages. Such structural differences also mean there is not an exact word-to-word correspondence, but the numbers in square brackets here correspond to the numbers in the Arabic passage, and in Appendix AA.
Appendix AA: Language features

The following conventions have been used in analysing the cloze passage. The first column shows the Arabic words that were deleted from the selected Physics textbook passage according to the cloze test procedure. The first item happened to be the English word ‘Law’, in ‘Newton’s Second Law’. While obviously not Arabic, its inclusion is valid here as a representation of the English insertions that pose part of the challenge of this textbook for Arabic readers. The second and third columns show the transliteration and English translation of each deleted word. The fourth column shows the part of speech according to Arabic grammar, and the fifth gives the transliteration and translation of the Arabic grammatical term (Cachia, 1973). The final column shows whether the deleted word was classified as technical, semi-technical or non-technical in the passage. The several Arabic terms translated as ‘noun’ (maṭūf, īsm majrūr, īsm īnna, tamīz, mubtada, khabar) refer to subtypes such as attributive noun, definite/indefinite noun, subject noun, predicate noun, object of a preposition. ‘Object’ and ‘genitive’ refer to nouns in accusative and genitive case respectively. Grammatical particles include conjunctions (wa), complementiser (anna), and conditionals (la’la, hatta).

<table>
<thead>
<tr>
<th>Gap No.</th>
<th>Deleted word</th>
<th>Transliteration</th>
<th>Translation</th>
<th>Part of speech</th>
<th>Transliteration of part of speech</th>
<th>Technical or semi-technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Law</td>
<td>_</td>
<td>[in English, i.e. Newton’s Second Law]</td>
<td>_</td>
<td>noun</td>
<td>semi-technical</td>
</tr>
<tr>
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<td>kāla</td>
<td>kullan</td>
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<td>mafʿūl bih (object)</td>
<td>non</td>
</tr>
<tr>
<td>(3)</td>
<td>الفيزيائي</td>
<td>al-fiziyāʾī</td>
<td>physical</td>
<td>معلومات</td>
<td>maṭūf (noun)</td>
<td>technical</td>
</tr>
<tr>
<td>(4)</td>
<td>fi</td>
<td>fy</td>
<td>in</td>
<td>حرف جر</td>
<td>ḥarf jar (preposition)</td>
<td>non</td>
</tr>
<tr>
<td>(5)</td>
<td>al-latī</td>
<td>which</td>
<td>صفة</td>
<td>صفة</td>
<td>ṣīfah (adjective)</td>
<td>non</td>
</tr>
<tr>
<td>Gap No.</td>
<td>Deleted word</td>
<td>Transliteration</td>
<td>Translation</td>
<td>Part of speech</td>
<td>Transliteration of part of speech</td>
<td>Technical or semi-technical</td>
</tr>
<tr>
<td>---------</td>
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<td>----------------</td>
<td>-------------</td>
<td>----------------</td>
<td>----------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>(6)</td>
<td>ان</td>
<td>anna</td>
<td>that</td>
<td>حرف ناسخ</td>
<td>ḥarf nāsikh (particle)</td>
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<td>(7)</td>
<td>شيء</td>
<td>shay‘</td>
<td>thing</td>
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<td>muḍāf ḫalāli (genitive)</td>
<td>non</td>
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<td>muhmalah</td>
<td>negated</td>
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<td>khabar īnna (predicate of īnna)</td>
<td>non</td>
</tr>
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<td>(9)</td>
<td>تؤثر</td>
<td>tu’ athir</td>
<td>affect</td>
<td>فعل مضارع</td>
<td>fi’l muḍūrī (present verb)</td>
<td>semi-technical</td>
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<td>(10)</td>
<td>حيث</td>
<td>ḥaythu</td>
<td>where</td>
<td>ظرف مكان</td>
<td>ḥarf makān (adverb of place)</td>
<td>non</td>
</tr>
<tr>
<td>(11)</td>
<td>g</td>
<td>-</td>
<td>[Eng. symbol: ‘g’]</td>
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<tr>
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<td>al-thālith</td>
<td>third</td>
<td>صفة</td>
<td>ṣīfah (adjective)</td>
<td>non</td>
</tr>
<tr>
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<td>يصبح</td>
<td>ywsbih</td>
<td>becomes</td>
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<td>fi’l muḍūrī (present verb)</td>
<td>non</td>
</tr>
<tr>
<td>(14)</td>
<td>لعلك</td>
<td>la’laka</td>
<td>perhaps you</td>
<td>لعل:حرف ناسخ + ضمير</td>
<td>ḥarf nāsikh (particle) + ḍamīr (pronoun)</td>
<td>non</td>
</tr>
<tr>
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<td>السابقة</td>
<td>al-sābiqah</td>
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<td>ṣīfah (adjective)</td>
<td>non</td>
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<td>yu’athirān</td>
<td>exert an effect</td>
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<td>fi’l muḍūrī (present verb)</td>
<td>semi-technical</td>
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<td>miqdār</td>
<td>the amount</td>
<td>اسم إن</td>
<td>īsm īnna (noun)</td>
<td>semi-technical</td>
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<tr>
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<td>مضروبة</td>
<td>maḍrūbah</td>
<td>multiplied by</td>
<td>حال</td>
<td>ḥāl (adverb)</td>
<td>semi-technical</td>
</tr>
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<td>as a result</td>
<td>مفعول لاجل</td>
<td>mafūl li ājlih (obj. of causation)</td>
<td>semi-technical</td>
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<td>الضروري</td>
<td>al-ḍarūrī</td>
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<td>īsm majrūr (noun)</td>
<td>non</td>
</tr>
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<td>al-jāthibiyah</td>
<td>gravity</td>
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<td>muḍāf ḫalāli (genitive)</td>
<td>technical</td>
</tr>
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<td>حتى</td>
<td>ḥatta</td>
<td>even</td>
<td>حرف (إيضاح)</td>
<td>ḥarf ībtidā (particle)</td>
<td>non</td>
</tr>
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<td>ḥurrān</td>
<td>free</td>
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<td>ṣīfah (adjective)</td>
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<td>al-ardh</td>
<td>the earth</td>
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<td>īsm majrūr (noun)</td>
<td>semi-technical</td>
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<td>ākhar</td>
<td>another</td>
<td>صفة</td>
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</tr>
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<td>Translation</td>
<td>Part of speech in the sentence</td>
<td>Transliteration of part of speech</td>
<td>Technical or semi-technical</td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
<td>----------------</td>
<td>-------------</td>
<td>--------------------------------</td>
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<td>---------------------------</td>
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<td>-</td>
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<td>technical</td>
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<tr>
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<td>wa</td>
<td>and</td>
<td>ḥarf ībtidā (particle)</td>
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<td></td>
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<td>min</td>
<td>from</td>
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</tr>
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<td></td>
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<td>īsm majrūr (noun)</td>
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<td></td>
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<tr>
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<td>al-mawāzin</td>
<td>scales</td>
<td>mubtada (noun)</td>
<td>technical</td>
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<td></td>
</tr>
<tr>
<td>(35)</td>
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<td>on</td>
<td>ḥarf jar (preposition)</td>
<td>non</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(36)</td>
<td>lā</td>
<td>on</td>
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<td>non</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(37)</td>
<td>ilā</td>
<td>to</td>
<td>ḥarf jar (preposition)</td>
<td>non</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>liʿānnaka</td>
<td>because you</td>
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<td>ḥarf jar (preposition)</td>
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<tr>
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<tr>
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<td>and</td>
<td>ḥarf ībtidā (particle)</td>
<td>non</td>
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<td></td>
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<tr>
<td>Gap No.</td>
<td>Deleted word</td>
<td>Transliteration</td>
<td>Translation</td>
<td>Part of speech</td>
<td>Transliteration of part of speech</td>
<td>Technical or semi-technical</td>
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<td>----------------</td>
<td>----------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>(41)</td>
<td>النابض</td>
<td>al-nābiḍ</td>
<td>spring</td>
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<td>muḍāf ilaḥ (genitive)</td>
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<td>a’lā</td>
<td>up</td>
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</tr>
<tr>
<td>(43)</td>
<td>Fg</td>
<td>_</td>
<td>[Eng. symbol: ‘force of gravity’]</td>
<td>_</td>
<td>[symbol]</td>
<td>technical</td>
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<tr>
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<td>أسفل</td>
<td>asfal</td>
<td>downward</td>
<td>اسم مجرور</td>
<td>ʾīsm majrūr (noun)</td>
<td>non</td>
</tr>
<tr>
<td>(45)</td>
<td>الشكل</td>
<td>al-shakl</td>
<td>figure</td>
<td>اسم مجرور</td>
<td>ʾīsm majrūr (noun)</td>
<td>semi-technical</td>
</tr>
<tr>
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<td>al-mīzān</td>
<td>scale</td>
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<td>muḍāf ilaḥ (genitive)</td>
<td>technical</td>
</tr>
<tr>
<td>(47)</td>
<td>بها</td>
<td>biha</td>
<td>by</td>
<td>هـ : حرف جر  +  ُdamīr (pronoun)</td>
<td>ḥarf jar (preposition)</td>
<td>non</td>
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<td>ما</td>
<td>ma</td>
<td>which</td>
<td>اسم إنّ</td>
<td>ʾīsm īnna (noun)</td>
<td>non</td>
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<td>الوزن</td>
<td>al-wazn</td>
<td>خبر</td>
<td>khabar (noun)</td>
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<td>al-kutlāh</td>
<td>mass</td>
<td>مضاف إليه</td>
<td>muḍāf ilaḥ (genitive)</td>
<td>technical</td>
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</table>
Appendix BB: Mean student conceptual score by nationality

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Mean conceptual total (/50)</th>
<th>No. of students</th>
<th>Arabic as L1?</th>
<th>Group Mean</th>
<th>Group No.</th>
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</thead>
<tbody>
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<td>Saudi</td>
<td>16.03</td>
<td>223</td>
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<td></td>
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<tr>
<td>Yemeni</td>
<td>18.92</td>
<td>39</td>
<td>Yes</td>
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<td>Jordanian</td>
<td>21.57</td>
<td>7</td>
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<td>Egyptian</td>
<td>21.42</td>
<td>19</td>
<td>Yes</td>
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<td>Syrian</td>
<td>19.72</td>
<td>18</td>
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<td>Palestinian</td>
<td>18.59</td>
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<td>Sudan</td>
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<td>345</td>
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<td>Somalia</td>
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<td>Eritrea</td>
<td>14.25</td>
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<td>3</td>
<td>No</td>
<td>13.87</td>
<td>15</td>
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<tr>
<td>Overall</td>
<td>17.22</td>
<td>360</td>
<td>-</td>
<td>17.22</td>
<td>360</td>
</tr>
</tbody>
</table>

The apparent difference between students coming from nations where Arabic is the medium of instruction (3.5/50=7%) is not statistically significant (F=2.465, Sig. = 0.117, p > 0.05). The small number of such students in this study makes reliance on this outcome unsafe.
### Appendix CC: Mean student conceptual score by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean conceptual total (/50)</th>
<th>No.</th>
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<td>18.93</td>
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<td>16</td>
<td>17.13</td>
<td>206</td>
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<td>17</td>
<td>13.71</td>
<td>32</td>
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<td>18</td>
<td>6.50</td>
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<td>19</td>
<td>.00</td>
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<td><strong>Missing</strong></td>
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<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>17.22</strong></td>
<td><strong>360</strong></td>
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</table>

### Appendix DD: Student difficulties with specific language features

<table>
<thead>
<tr>
<th>Category</th>
<th>No of items</th>
<th>Reliability Cronbach α</th>
<th>Mean % wrong</th>
<th>Std Dvn</th>
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</thead>
<tbody>
<tr>
<td>Noun</td>
<td>13</td>
<td>0.682</td>
<td>74.63</td>
<td>17.249</td>
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<tr>
<td>Adjective</td>
<td>6</td>
<td>0.481</td>
<td>58.98</td>
<td>23.594</td>
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<td>Genitive</td>
<td>5</td>
<td>0.476</td>
<td>52.87</td>
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<td>Particle</td>
<td>4</td>
<td>0.484</td>
<td>55.00</td>
<td>28.16</td>
</tr>
<tr>
<td>Preposition</td>
<td>7</td>
<td>0.690</td>
<td>50.79</td>
<td>28.62</td>
</tr>
<tr>
<td>Verb</td>
<td>3</td>
<td>0.383</td>
<td>45.00</td>
<td>32.90</td>
</tr>
<tr>
<td>Prepositional phrase</td>
<td>4</td>
<td>0.416</td>
<td>71.25</td>
<td>26.84</td>
</tr>
<tr>
<td>Symbol</td>
<td>3</td>
<td>0.164</td>
<td>87.96</td>
<td>17.68</td>
</tr>
<tr>
<td>Technical</td>
<td>9</td>
<td>0.586</td>
<td>72.99</td>
<td>17.88</td>
</tr>
<tr>
<td>Semi-technical</td>
<td>11</td>
<td>0.582</td>
<td>68.03</td>
<td>16.85</td>
</tr>
<tr>
<td>Non-technical</td>
<td>30</td>
<td>0.855</td>
<td>62.41</td>
<td>19.84</td>
</tr>
</tbody>
</table>

**Key:** @ N > 3, α > 0.5
Appendix EE: Teacher Interview Questions:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Curriculum</strong></td>
<td>Can you please compare between the old and the new physics curriculum (e.g. adequacy, features)? Do you think that the new curriculum achieves the aims that have been designed for? What do you recommend?</td>
</tr>
<tr>
<td></td>
<td>How do you find students’ interaction with this new curriculum?</td>
</tr>
<tr>
<td></td>
<td>What do you advise other teachers to help student to cope with?</td>
</tr>
<tr>
<td><strong>Resources</strong></td>
<td>Do you think that the number of weekly physics classes is enough to cover the whole curriculum? If yes, what do you suggest for the access time? If not, how many weekly classes do you suggest? Why?</td>
</tr>
<tr>
<td></td>
<td>Do you refer to external resources to prepare lessons? Please specify if yes. If not, do not you think that it is better to refer to external resources in addition to the textbook?</td>
</tr>
<tr>
<td></td>
<td>Do you encourage your students to search for new information? Why?</td>
</tr>
<tr>
<td></td>
<td>To what extend do you refer to foreign external references to prepare lessons? How easy is doing that?</td>
</tr>
<tr>
<td><strong>Language</strong></td>
<td>Do you experience difficulties in using English and Arabic at the same times? What is the best for students to use? And for you?</td>
</tr>
<tr>
<td></td>
<td>Do you use English numbers, names of units, and physical symbols or do you just use the Arabic ones? Why?</td>
</tr>
</tbody>
</table>
Appendix FF: The full set of questionnaire items corresponding to each factor:

<table>
<thead>
<tr>
<th>Label</th>
<th>Questions</th>
<th>Mean%</th>
<th>Std%</th>
<th>Almost every day(6)</th>
<th>Often (5)</th>
<th>Sometimes (4)</th>
<th>Not very much (3)</th>
<th>Very rarely (2)</th>
<th>Never (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude toward learning physics</td>
<td>*I love scientific lessons, which are taught in laboratory.</td>
<td>4.65</td>
<td>1.23</td>
<td>26.1(94)*</td>
<td>35.8(129)</td>
<td>26.1(94)</td>
<td>5.3(19)</td>
<td>2.5 (9)</td>
<td>3.9 (14)</td>
</tr>
<tr>
<td></td>
<td>*I like to perform all practical experiments in the laboratory because experiments help me to understand.</td>
<td>4.88</td>
<td>1.47</td>
<td>47.8(172)</td>
<td>22.5(81)</td>
<td>15.3(55)</td>
<td>6.1(22)</td>
<td>2.8(10)</td>
<td>3.6(13)</td>
</tr>
<tr>
<td></td>
<td>Colorful design of physics book helps me to understand.</td>
<td>4.64</td>
<td>1.50</td>
<td>38.9(140)</td>
<td>24.7(89)</td>
<td>14.4(52)</td>
<td>11.7(42)</td>
<td>4.2(15)</td>
<td>5.8(21)</td>
</tr>
<tr>
<td></td>
<td>*The physics book is clear and interesting.</td>
<td>2.79</td>
<td>1.56</td>
<td>5.3(19)</td>
<td>10.0(36)</td>
<td>19.7(71)</td>
<td>18.6(67)</td>
<td>17.8(64)</td>
<td>26.7(96)</td>
</tr>
<tr>
<td>Supportive school environment</td>
<td>There is a very convenient educational environment in my school.</td>
<td>3.98</td>
<td>1.76</td>
<td>26.4(95)</td>
<td>19.4(70)</td>
<td>15.6(56)</td>
<td>14.7(53)</td>
<td>12.5(45)</td>
<td>10.8(39)</td>
</tr>
<tr>
<td></td>
<td>*School is my second home.</td>
<td>3.33</td>
<td>1.89</td>
<td>15.8(57)</td>
<td>19.7(71)</td>
<td>15.8(57)</td>
<td>8.9(32)</td>
<td>10.8(39)</td>
<td>27.8(100)</td>
</tr>
<tr>
<td></td>
<td>The laboratory technician exerts much effort to help us to understand practical sections of the lesson.</td>
<td>4.64</td>
<td>1.46</td>
<td>14.3(145)</td>
<td>19.7(71)</td>
<td>17.5(63)</td>
<td>14.2(51)</td>
<td>4.4(16)</td>
<td>2.8(10)</td>
</tr>
<tr>
<td>General literacy</td>
<td>I read other things apart from schoolwork.</td>
<td>3.92</td>
<td>1.99</td>
<td>35.3(127)</td>
<td>13.6(49)</td>
<td>12.2(44)</td>
<td>6.7(24)</td>
<td>10.8(39)</td>
<td>21.4(77)</td>
</tr>
<tr>
<td></td>
<td>*I buy some commercial books from book stores to simplify studying.</td>
<td>3.06</td>
<td>1.83</td>
<td>13.1(47)</td>
<td>14.2(51)</td>
<td>16.9(61)</td>
<td>10.0(36)</td>
<td>13.9(50)</td>
<td>31.4(113)</td>
</tr>
<tr>
<td></td>
<td>I read only the school work.</td>
<td>3.59</td>
<td>1.72</td>
<td>17.2(62)</td>
<td>18.6(67)</td>
<td>18.9(68)</td>
<td>14.2(51)</td>
<td>13.9(50)</td>
<td>17.2(62)</td>
</tr>
<tr>
<td></td>
<td>*I love to know more about the latest inventions all over the world.</td>
<td>4.11</td>
<td>1.80</td>
<td>31.1(112)</td>
<td>18.1(65)</td>
<td>20.0(72)</td>
<td>8.3(30)</td>
<td>8.3(30)</td>
<td>11.9(43)</td>
</tr>
<tr>
<td>Physics readability</td>
<td>I can understand the lessons which I couldn’t attend at school through reading the book.</td>
<td>3.13</td>
<td>1.63</td>
<td>7.2(26)</td>
<td>16.4(59)</td>
<td>21.4(77)</td>
<td>18.1(65)</td>
<td>11.7(42)</td>
<td>24.7(89)</td>
</tr>
<tr>
<td></td>
<td>I can extract the main information of a physics lesson through reading the book.</td>
<td>3.98</td>
<td>1.51</td>
<td>17.2(62)</td>
<td>22.8(82)</td>
<td>28.3(102)</td>
<td>13.3(48)</td>
<td>9.4(34)</td>
<td>8.1(29)</td>
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</tr>
<tr>
<td><strong>Attitude toward Science</strong></td>
<td>I love to read and observe the updates in Science and knowledge and watch the scientific programs on TV.</td>
<td>3.29</td>
<td>1.80</td>
<td>15.8(57)</td>
<td>14.2(51)</td>
<td>18.1(65)</td>
<td>12.8(46)</td>
<td>14.2(51)</td>
<td>24.7(89)</td>
</tr>
<tr>
<td></td>
<td>My teacher translates all scientific symbols into Arabic.</td>
<td>3.96</td>
<td>1.80</td>
<td>27.5(99)</td>
<td>17.5(63)</td>
<td>20.8(75)</td>
<td>8.9(32)</td>
<td>10.0(36)</td>
<td>13.6(49)</td>
</tr>
<tr>
<td></td>
<td>My school supports research and experiments which students do outside the school.</td>
<td>3.09</td>
<td>1.85</td>
<td>15.0(54)</td>
<td>13.1(47)</td>
<td>14.2(51)</td>
<td>13.9(50)</td>
<td>13.9(50)</td>
<td>28.1(101)</td>
</tr>
<tr>
<td><strong>Learning habits</strong></td>
<td>One of my brothers or sisters helps me in doing my homework and studying.</td>
<td>2.85</td>
<td>1.90</td>
<td>12.2(44)</td>
<td>14.2(51)</td>
<td>14.4(52)</td>
<td>7.5(27)</td>
<td>10.3(37)</td>
<td>40.0(144)</td>
</tr>
<tr>
<td></td>
<td>Using English in physics book makes it more difficult.</td>
<td>4.15</td>
<td>1.91</td>
<td>36.1(130)</td>
<td>16.7(60)</td>
<td>15.8(57)</td>
<td>9.2(33)</td>
<td>5.3(19)</td>
<td>13.6(49)</td>
</tr>
<tr>
<td><strong>Teacher uses MSA</strong></td>
<td>My teacher uses the standard Arabic language inside the classroom.</td>
<td>3.19</td>
<td>1.81</td>
<td>10.6(38)</td>
<td>20.8(75)</td>
<td>15.8(57)</td>
<td>13.6(49)</td>
<td>10.8(39)</td>
<td>25.3(91)</td>
</tr>
</tbody>
</table>

**Notes:**

* Likert scale: Agreement (scale was frequency for the other items).

1 % (number)

2 mean Likert ‘score’ from a six point scale
Appendix GG: Student Survey

I. Students’ General Information:

Please answer all of the following questions by choosing the appropriate choice:

1. Student’s Name:
2. Class:
3. School’s Name:
   | □ ----- school | □ |
4. Nationality:
   | □ Saudi | □ Non-Saudi |
   | Please specify: |
5. Have you ever studied abroad?
   | □ No | □ Yes |
   | If yes, specify |
6. Father’s highest level of education:
   | □ Informal education | □ Less than secondary school |
   | □ Secondary school | □ Diploma |
   | □ Bachelor | □ Post graduate |
   | □ Other, please specify |
7. Mother’s highest level of education:
   | □ Informal education | □ Less than secondary school |
   | □ Secondary school | □ Diploma |
   | □ Bachelor | □ Post graduate |
   | □ Other, please specify |
II. Student questionnaire:

For each of the following statements decide whether you *(6, Almost every day (5, often (4), sometimes or (3), not very much (2), very rarely (1), never*, with each statement. Please note that there is no correct answer.

<table>
<thead>
<tr>
<th>S</th>
<th>Statement</th>
<th>6: Almost every day</th>
<th>5: Often</th>
<th>4: Sometimes</th>
<th>3: Not very much</th>
<th>2: Very rarely</th>
<th>1: Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I depend on myself in doing my homework and studying.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>The laboratory technician exerts much effort to help us to understand practical sections of the lesson.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>3</td>
<td>I can extract the main information of a physics lesson through reading the book.</td>
<td></td>
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<tr>
<td>4</td>
<td>I attend some private tutoring when required.</td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>Before asking my teacher’s help, I would prefer to ask one of my colleagues to help me</td>
<td></td>
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<tr>
<td>6</td>
<td>My school’s library offers all required references.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7</td>
<td>My teacher uses the classic language inside the classroom.</td>
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<tr>
<td>8</td>
<td>My family supports me to excel, succeed, and doesn’t force me to do much housework.</td>
<td></td>
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<tr>
<td>9</td>
<td>Figures and graphs in the physics book help me to understand.</td>
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<tr>
<td>10</td>
<td>I am keen to integrate with excellent students at school.</td>
<td></td>
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<tr>
<td>11</td>
<td>I love scientific activities which are held in our school and I take part in them.</td>
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</tr>
<tr>
<td>12</td>
<td>My teacher uses the classical language <em>(al-fushā)</em> inside the classroom.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>13</td>
<td>I can understand and memorize the physics symbols in English easily.</td>
<td></td>
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<tr>
<td>14</td>
<td>The physics laboratory has most of the necessary equipment for physics experiments.</td>
<td></td>
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</tr>
<tr>
<td>15</td>
<td>The Colorful design of the Physics book helps me to understand.</td>
<td></td>
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</tr>
<tr>
<td>16</td>
<td>I read school work.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>17</td>
<td>I like the use of PowerPoint shows in teaching lessons.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>18</td>
<td>Classrooms in my school are equipped with teaching aids, computers, data show projectors to help us to understand the scientific subjects.</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>19</td>
<td>I can understand the lessons which I couldn’t attend at school through reading the textbook.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>I love to read and observe the updates in Science and knowledge and watch the scientific programs on TV.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>21</td>
<td>There is a very convenient educational environment in my school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>One of my brothers or sisters helps me in doing my homework and studying.</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>23</td>
<td>I like the use of video clips in teaching.</td>
<td></td>
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</tr>
<tr>
<td>24</td>
<td>My teachers are using technology, teaching aids and power point presentations in teaching scientific courses.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>25</td>
<td>I don’t hesitate to ask one of my teachers to help me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Using English in the Physics book makes it more difficult.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>I prefer to study from prepared course summaries, not from the official textbooks.</td>
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<td>----------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>28</td>
<td>I meet with my colleagues outside the school to study and do homework.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>29</td>
<td>My teacher translates all scientific symbols into Arabic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>I don’t hesitate to ask my teacher to re-explain what I don’t understand during the class.</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>31</td>
<td>I love to watch educational programs at home.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>My teachers support and encourage excellent students.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>I use some foreign materials and Arabic references in studying.</td>
<td></td>
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</tr>
<tr>
<td>34</td>
<td>I read things that are not connected to school work</td>
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</tr>
</tbody>
</table>
For each of the following statements decide whether you (6) strongly Agree (5) Agree (4) little agree or (3) little Disagree (2) disagree, (1) strongly disagree, with each statement. Please note that there is no correct answer.

<table>
<thead>
<tr>
<th>S</th>
<th>Statement</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>I love the scientific lessons which are taught in the laboratory.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>I appreciate my teacher efforts to make Physics an easy course for me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>37</td>
<td>My school offers a well-equipped laboratory for physics experiments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>38</td>
<td>It is okay for me to do research papers when my teachers ask for that.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Laws in the physics book are expressed in a very simplified way.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>I love my teacher because she is the one who teaches me.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>School is my second home.</td>
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<tr>
<td>42</td>
<td>I love to know more about the latest inventions all over the world.</td>
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<tr>
<td>43</td>
<td>I love physics because I love my physics teacher.</td>
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<tr>
<td>44</td>
<td>I like to perform all practical experiments in the laboratory because experiments help me to understand quickly.</td>
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<td>45</td>
<td>My school offers safety equipment at laboratories.</td>
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<tr>
<td>46</td>
<td>The physics book is clear and interesting.</td>
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<tr>
<td>47</td>
<td>My teacher has a good command of English language.</td>
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<tr>
<td>48</td>
<td>I buy some commercial books from book stores to simplify studying.</td>
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