Reading Difficulty and Language Features in an Arabic Physics Text

Nouf Mohammed Albadi
Ministry of Education, Saudi Arabia
University of Newcastle, Australia

John Mitchell O'Toole
University of Newcastle, Australia

Jean Harkins
University of Newcastle, Australia

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 the Arabic used in a mandatory Saudi Year 10 Physics textbook. Findings reveal that: (a) These 360 female students appear to be having significant difficulty understanding their textbook. (b) Nouns seem to cause the greatest difficulty, followed by technical- and semi-technical words; adjectives and grammatical particles. (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.

Key words: Arabic, Physics, Language, Reading, Cloze

Please address all correspondence to: Nouf Mohammed Albadi, University of Newcastle, Callaghan, NSW, Australia, C3086763@uon.edu.au

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 post school 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 ***science*** text (Morrow, Gambrell, & Pressley, 2008), which require 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). Students' 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 student 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 thirty million people speak Arabic as a first language and 1.4 billion people use the classical form for religious purposes (C.I.A. 2008). 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.

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; 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).

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.

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 1). Appendices preserve both the Arabic original (Appendix 1) and an English translation (Appendix 2).

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 fifty 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 of lasts 45 minutes this was the time available for student completion of the cloze test (see Appendix 1).

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 3). 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 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, where in horticulture it refers to the soil. Non-technical items are words widely found in everyday use, for example, 'thing' *(shayʾ)*.

Procedure

The first 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.

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*** grammatical 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 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 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 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 (α = 0.892).

Use of the broad conceptual total (and associated error total) will allow comparison of participant responses to differing language features.

Table 1 Overall cloze test scores

Category	No of items	Reliability (Cronbach α)	Mean	Std Dvn
Conceptual total	50	0.896	34.44% ***Conceptually correct***	16.94
Error total	50	0.892	65.54% ***Clearly wrong***	16.94
Exact total	50	0.829	20.86	10.806

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 that but increases the confidence that can be placed in that discussion.

Table 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 2 Students' difficulties with specific language features (full data in Appendix 6)

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

Technicality issues. Sub-analysis of the students' 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 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 4&5*). 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 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 who had not previously studied this passage (see bold text on Table 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 3 Impact of prior knowledge:
Students at Jeddah 3 had done work on gravity

School number	Mean Conceptual Total (%)	N	Std Dvn
Jeddah 1	37.54	65	9.532
Jeddah 2	35.08	67	8.541
Jeddah 3	**37.02**	**59**	**8.351**
Abha 1	33.38	58	7.519
Abha 2	31.78	56	7.512
Abha 3	31.10	55	8.859
Total	34.44	360	8.472

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

students' reading ability fell into the frustration level (Al-Badrany, 2014; 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 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 reader 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 preposition and 71.25% for the slightly less reliable prepositional phrase.

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 participating students' reading of science 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 Ríordáin, 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 questions of how more effectively to communicate and develop learners' understanding are addressed.

Existing research indicates 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 student 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. The single student from Turkestan outperformed all others, although she did not come from an Arabic-medium nation and the 19 Egyptian students appeared to have less difficulty with this Physics passage than their Saudi classmates did.

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, 2017). 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 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 dialect difference between Jeddah and Abha. However, greater dialectal distance may have a greater impact than these results indicate (see Table 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.

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 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. Parent 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 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 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 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 in future research.

There is abundant opportunity for further 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.

Acknowledgments:

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

Mr. Ahmed Habib
Arabic Language Teacher

Mr. Abdullah Almatrafi
Master of Applied Linguistics
A lecturer at the English Language centre
Jeddah College of Technology

References

Abanami, A. A. (1982). *Readability analysis of the 11th and 12th grade Earth Science textbooks used in the public schools in Saudi Arabia.* (Unpublished PhD Thesis), University of Houston.

Abu-Hamour, B., Al-Hmouz, H., & Kenana, M. (2013). The effect of short vowelization on curriculum-based measurement of reading fluency and comprehension in Arabic. *Australian Journal of Learning Difficulties, 18*(2), 181-197.

Abu-Rabia, S. (1997). Reading in Arabic orthography: The effect of vowels and context on reading accuracy of poor and skilled native Arabic readers. *Reading and Writing, 9*(1), 65-78.

Albadi, N., O'Toole, J.M. & Harkins, J. (2016). Teacher perceived readability of Saudi school texts. *Canadian International Journal of Social Science and Education, 5*, 299-316.

Al-Badrany, A. (2014). *The relationship between Biology textbooks and achievement of year 10 in Al-Qassim educational region.[in Arabic]*. (Unpublished master thesis), Umm Al-Qura, Makkah. Retrieved from http://search.mandumah.com/Record/648765 (in Arabic).

Al-Dahmash, A. H., Mansour, N. S., Al-Shamrani, S. M., & Al-Mohi, S. (2016). An analysis of activities in Saudi Arabian middle school science textbooks and workbooks for the inclusion of essential features of inquiry. *Research in Science Education, 46*(6), 879-900.

Al-Ghamdi, H., & Al-Salouli, S. (2012). Saudi elementary school science teachers' beliefs: Teaching science in the new millennium. *International Journal of Science and Mathematics Education, 11*(2), 501-525.

Al-Mutalq, H. M. (1981). *Saudi Arabian attitudes to the education of children.* Riyadh, Saudi Arabia: Sciences' House for Printing and Publication. (in Arabic).

Al-Harbi, K. (2014). *Readabilty of science textbook for Grade 9 and the relationship to academic performance.* (Unpublished doctoral thesis), Yarmouk University, Jordan. Retrieved from http://search.mandumah.com/Record/720151 (in Arabic).

Al-Heeti, K. N. (1984). *Judgment analysis technique applied to readability prediction of Arabic reading material* (Unpublished doctoral thesis), University of Northern Colorado, Greeley, Colorado.

Al-Matrafi, G. (2010). The relationship between the readability of science text-book, achievment system and type of education of the first class students in the Elementary school in Saudi Arabia. *Journal of Faculty of Education, University of Benha, 21*(83), 91-160. (in Arabic).

Al-Shamrani, S. M. (2012). The inclusion of essential features of inquiry in the lab activities in Saudi eleventh grade Physics textbooks. *International Journal of Educational Research., 31*(1), 122-151. (in Arabic).

Al-Sheikh, N., Parameswaran, G, & Elhoweris, H. (2010). Parenting style, self-esteem and student performance in the United Arab Emirates. *Current Issues in Education*, 13(1). Retrieved from https://cie.asu.edu/ojs/index.php/cieatasu/article/view/265 .

Al-Yousef, H. (2009). 'They know nothing about university - neither of them went': The effect of parents' level of education on their involvement in their daughters' higher education choices. *Compare, 39*(6), 783-798.

Alderson, J. C. (1979). The cloze procedure and proficiency in English as a foreign language. *TESOL Quarterly, 13*(2), 219-227.

Ambosae'di, A., & Al-Erimi, B. (2004). The readability of Biology textbook (Grade 1 secondary) as related to some variables. *Educational Journal, Oman, 19*(73), 152-180. (in Arabic).

Bachman, L. F. (1985). Performance on cloze tests with fixed-ratio and rational deletions. *TESOL Quarterly, 19*(3), 535-556.

Badi, G. (1982). Cloze test trial in Arabic language in primary school. *Arabic Language Institute Journal, 1*(1), 313-327. (in Arabic).

Basit, T. N. (1997). 'I want more freedom, but not too much': British Muslim girls and the dynamism of family values. *Gender and Education, 9*(4), 425-440.

Belkhouche, B., Harmain, H., Al-Taha, H., Al-Najjar, L., & Tibi, S. (2010). *Analysis of primary school Arabic language textbooks.* Paper presented at the International Arab conference on information technology (ACIT), Retrieved from http://itpapers.info/acit10/Papers/f575.pdf .

Bormuth, J. R. (1968). The cloze readability procedure. *Elementary English, 45*(4), 429-436.

Boujaoude, S., & Gholam, G. (2014). The middle east: Egypt, Lebanon, and Saudi Arabia. In B. T. Vlaardingerbroek & N. Taylor (Eds.), *Issues in Upper Secondary Science Education: Comparative Perspectives*. (pp. 243-260). New York: Springer.

Britt, M.A., Richter, T. & Rouet, J. F. (2014) Scientific Literacy: The Role of Goal-Directed Reading and Evaluation in Understanding Scientific Information, *Educational Psychologist, 49*(2), 104-122,

Brooks, S. S. (1926). A study of the technical and semi-technical vocabulary of Arithmetic. *Educational Research Bulletin, 5*(11), 219-222.

Brown, C. H. (1985). Polysemy, overt marking, and function words. *Language Sciences, 7*(2), 283-332.

Brown, J. D. (1980). Relative merits of four methods for scoring cloze tests. *The Modern Language Journal, 64*(3), 311-317.

Brown, P., & Concannon, J. (2016). Students' perceptions of vocabulary knowledge and learning in a middle school science classroom. *International Journal of Science Education, 38*(3), 391-408.

Bugahoos, K. A., & Ismaeel, A. E. (2001). Measurement of readability level of Organisms and Environment textbook for secondary school in the State of Bahrain. *The Education Research Centre Journal, 10*(19), 109-133. (in Arabic).

Burton, R. S. (2014). Readability, logodiversity, and the effectiveness of college science textbooks. *Bioscene, 40*(1), 3-10.

Bybee, R. W. (1995). Achieving scientific literacy. *The Science Teacher, 62*(7), 28-33.

Cachia, P. (1973). *The monitor: A dictionary of Arabic grammatical terms: Arabic-English, English-Arabic*. Beirut: Librairie du Liban.

Chall, J. S. (1988). The beginning years. In B. L. Zakaluk & S. J. Samuels (Eds.), *Readability: Its past, present and future* (pp. 2-13). Newark, DE: International Reading Association.

Chrzanowski, M. M., Cieszyńska, A., & Ostrowska, B. (2015). Communication during science classes. *Procedia: Social and Behavioral Sciences, 174*, 496-502.

C.I.A. (2008). *CIA World Fact Book*. Retrieved from https://www.cia.gov/library/publications/resources/the-world-factbook/geos/dj.html

Cowan, J. R. (1974). Lexical and syntactic research for the design of EFL reading materials. *TESOL Quarterly, 8*(4), 389-399.

DuBay, W. H. (2004). *The principles of readability*. Retrieved from https://eric.ed.gov/?id=ED490073

Dwairy, M., Achoui, M., Abouserie, R., Farah, A. (2006a). Adolescent-family connectedness among Arabs: A second cross-regional research study. *Journal of Cross-Cultural Psychology, 37*(3), 248-261.

Dwairy, M., Achoui, M., Abouserie, R., Farah, A., Sakhleh, A. A., Fayad, M., & Khan, H. K. (2006b). Parenting Styles in Arab Societies A First Cross-Regional Research Study. *Journal of Cross-Cultural Psychology, 37*(3), 230-247.

Eccles, J. S. (1993). School and family effects on the ontogeny of children's interests, self-perceptions, and activity choices. In J. Jacobs (Ed.), *Nebraska Symposium on Motivation 40*, 145-208. Lincoln, NE: University of Nebraska Press.

El-Biza, N. (2010). *Becoming me: Perceptions of identity and self-efficacy among Australian and Saudi Arabian Muslim girls*. (Doctoral dissertation). Faculty of Education, University of Wollongong. Retrieved from http://ro.uow.edu.au/theses/3328

Fang, Z. (2005). Scientific literacy: A systemic functional linguistics perspective. *Science Education, 89*(2), 335-347.

Gee, J. P. (2003). Opportunity to Learn: a language-based perspective on assessment. *Assessment in Education: Principles, Policy & Practice, 10*(1), 27 - 46.

Ghani, K. A., Noh, A. S., & Yusoff, N. M. (2014). Linguistic features for development of Arabic text readability formula in Malaysia: A preliminary study. *Middle-East Journal of Scientific Research, 19*(3), 319-331.

Gilbert, C. C. (1984). *The reading strategies used by selected adult Spanish and Arabic readers in their native language and in English.* (Doctoral thesis), University of Illinois at Urbana-Champaign, Illinois, USA.

Gilliland, J. (1972). *Readability*. London: University of London Press.

Gunning, T. (2002). *Assessing and correcting reading and writing difficulties*. Boston: Allyn & Bacon.

Halliday, M. A. (1993). Towards a language-based theory of learning. *Linguistics and Education, 5*(2), 93-116.

Hand, B., Yore, L. D., Jagger, S., & Prain, V. (2010). Connecting research in science literacy and classroom practice: a review of science teaching journals in Australia, the UK and the United States, 1998-2008. *Studies in Science Education, 46*(1), 45-68.

Herman, P., Perkins, K., Hansen, M., Gomez, L., & Gomez, K. (2010). The effectiveness of reading comprehension strategies in high school science classrooms. Paper presented at *Learning in the Disciplines: Proceedings of the 9th International Conference of the Learning Sciences, ICLS '10*, Chicago, IL, USA, June 29 - July 2, *Vol. 1*, Retrieved from

https://www.researchgate.net/publication/220934386_The_Effectiveness_of_Reading_Comprehension_Strategies_in_High_School_Science_Classrooms

Herman, P., & Wardrip, P. (2012). Reading to learn. *The Science Teacher, 79*(1), 48-51.

Hinton, P. R., McMurray, I., & Brownlow, C. (2004). *SPSS explained*. London: Routledge.

Kadbey, H., Dickson, M., & McMinn, M. (2015). Primary teachers' perceived challenges in teaching science in Abu Dhabi public schools. *Procedia: Social and Behavioral Sciences, 186*, 749-757.

Ktait, G. Y. (2002). *Evaluation of the second year secondary Physics textbook and the level of its readability* (unpublished Master's thesis), Amman Arab University (in Arabic).

Lancioni, G., & Bettini, L. (Eds.). (2011). *The word in Arabic*. Boston: Brill.

Lemke, J. L. (2004). The literacies of science. In E. W. Saul (Ed.), *Crossing borders in literacy and science instruction: Perspectives on theory and practice* (pp. 33-47). Newark, DE: International Reading Association.

Lively, B. A., & Pressey, S. L. (1923). A method for measuring the 'vocabulary burden' of textbooks. *Educational Administration and Supervision, 9*, 389-398.

Martin, M., Mullis, I., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International results in science*. Retrieved from http://timssandpirls.bc.edu/timss2015/international-results/download-center/

McGraw-Hill. (n.d.). *Company webpage*, Retrieved from https://www.mheducation.com/home.html

Menon, S., & Mukundan, J. (2010). Analysing collocational patterns of semi-technical words in science textbooks. *Pertanika Journal of Social Sciences & Humanities, 18*(2), 241-258.

Mikk, J., & Kukemelk, H. (2010). The relationship of text features to the level of interest in science texts. *TRAMES: A Journal of the Humanities & Social Sciences, 14*(1), 54-70.

Ministry of Education. (2017). *The quarterly system in secondary schools.* Retrieved from https://www.moe.gov.sa/ar/Alfasly/Pages/AboutProject.aspx (in Arabic).

Mohamed, W., Elbert, T., & Landerl, K. (2011). The development of reading and spelling abilities in the first 3 years of learning Arabic. *Reading & Writing, 24*(9), 1043-1060.

Morrow, L. M., Gambrell, L. B., & Pressley, M. (Eds.). (2008). *Comprehension instruction: Research-based best practices* (2nd ed.). New York: Guilford Press.

Murcia, K. (2009). Re-thinking the development of scientific literacy through a rope metaphor. *Research in Science Education, 39*(2), 215-229.

Nation, I. S. P. (2001). *Learning vocabulary in another language*. Cambridge: Cambridge University Press.

Ncube, M. (2015). *Investigating the learners' interpretation of everyday words when used in the Physics context in South African classrooms.* (Master thesis), University of the Witwatersrand, Johannesburg.

Ní Ríordáin, M., Coben, D., & Miller-Reilly, B. (2015). What do we know about Mathematics teaching and learning of multilingual adults and why does it matter? *Adults Learning Mathematics, 10*(1), 8-23.

Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*(2), 224-240.

Nwesri, A., Tahaghoghi, S., & Scholer, F. (2005). Stemming Arabic conjunctions and prepositions. In *International Symposium on String Processing and Information Retrieval. 3772*, 206-217. Berlin: Springer.

Obeikan Education. (2013). *General information.* Retrieved from http://obeikaneducation.com/obeikanmodules/

Oller, J. W., & Conrad, C. A. (1971). The cloze technique and ESL proficiency. *Language Learning, 21*(2), 183-194.

Oller, J. W., & Jonz, J. (1994). *Cloze and coherence*. London: Bucknell University Press.
Osborne, J. (2014). Teaching scientific practices: Meeting the challenge of change. *Journal of Science Teacher Education, 25*(2), 177-196.
O'Toole, J. M. (1996). Science, schools, children and books: Exploring the classroom interface between science and language. *Studies in Science Education, 28*, 113-143.
O'Toole, J.M., Cheng, J.Y. & O'Toole, G. (2015) An enduring lens for a continuing problem: Close analysis of conceptually scored cloze items. *Language Testing in Asia, 5*(1), Retrieved from https://link.springer.com/article/10.1186/s40468-015-0015-3
O'Toole, J.M. & King, R.A.R. (2010). Reading by the numbers: Reconsidering numerical estimates of readability, *The International Journal of Learning, 17*(10), 181-194
O'Toole, J.M. & Laugesen, R. (2011). *Developing specialist language styles: Research and application,* Sydney: Boraga Academic.
Phillips, L. M., & Norris, S. P. (2009). Bridging the gap between the language of Science and the language of school: Science through the use of adapted primary literature. *Research in Science Education, 39*(3), 313-319.
Rafee, A. M., Hadad, Z. Y., Sabag, E. F., & Alorani, A. A. (2014). *Physics: Year 1 Secondary first semester*. Riyadh, KSA: Obeikan/McGraw-Hill.
Roberts, K., Takahashi, K., Hye-Jin, P., & Stodden, R. A. (2012). Supporting struggling readers in secondary school Science classes. *Teaching Exceptional Children, 44*(6), 40-48.
Rollnick, M. (2000). Current issues and perspectives on second language learning of science. *Studies in Science Education, 35*, 93-122.
Rosenthal, J. W. (1996). *Teaching science to language minority students:Theory and practice.* Clevedon: Mulitllingual Matters.
Ryding, K. C. (2005). *A reference grammar of modern standard Arabic.* Cambridge: Cambridge University Press.
Saady, A., Ibrahim, R., & Eviatar, Z. (2015). Language-specific and language-general factors in text reading in Arabic: Evidence from the missing letter effect. *Psicológica, 36*(1), 123-142.
Saiegh-Haddad, E., & Schiff, R. (2016). The impact of diglossia on voweled and unvoweled word reading in Arabic: A developmental study from childhood to adolescence. *Scientific Studies of Reading, 20*(4), 311-324.
Sesi, G. H. (1982). *Validity of cloze procedure as an index of readability of Arabic language reading materials.* (Doctoral thesis), Wayne State University, Detroit, MI.
Stevens, K. T., Stevens, K. C., & Stevens, W. P. (1992). Measuring the readability of business writing: The cloze procedure versus readability formulas. *Journal of Business Communication, 29*(4), 367-382.
Swales, J. M. (1985). *Episodes in ESP: A source and reference book on the development of English for science and technology*. Oxford: Pergamon Press.
Taylor, W. L. (1953). Cloze procedure: a new tool for measuring readability. *Journalism and Mass Communication Quarterly, 30*(4), 415.
Taylor, W. L. (1956). Recent developments in the use of 'cloze procedure'. *Journalism & Mass Communication Quarterly, 33*(1), 42-99.
Toiemah, R. (1978). *The use of cloze to measure the proficiency of students of Arabic as a second language in some universities in the in the United States.* (Doctoral thesis), University of Minnesota, Minneapolis, MN.
Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. Phildelphia: Open University Press.

Yushau, B., & Bokhari, M. (2005). Language and mathematics: A mediational approach to bilingual Arabs. *International Journal for Mathematics Teaching and Learning, (April)*, 1-18.

Appendix 1

٤-٢ استخدام قوانين نيوتن Using Newton's laws

تم حذف بعض الكلمات من النص و إستبدالها بالارقام. اكتبي الكلمة المناسبة في ورقة الاجابة عند الرقم المناسب.

يربط قانون نيوتن الثاني بين السبب في تغير السرعة المتجهة للجسم ومقدار الإزاحة الناتجة ، ويحدد كذلك العلاقة بين القوة المحصلة التي تؤثر في جسم وتسارع هذا الجسم.

استخدام قانون نيوتن الثاني .....(١)..... Using Newton's Second

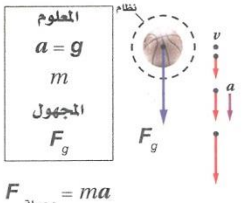
تأمل .....(٢)..... من النموذجين : التصويري و.....(٣)..... لكرة تسقط سقوطا حرا .....(٤).....الشكل 4-6. ما القوى.....(٥).....تؤثر في الكرة ؟ بما .....(٦).....الكرة لا تلمس أي .....(٧).....ولأن مقاومة الهواء .....(٨).....فإن القوة الوحيدة التي .....(٩)..... فيها هي F_g و .....(١٠)..... إن تسارع الكره هو .....(١١)..... (كما درست في الفصل .....(١٢).....) فإن القانون الثاني لنيوتن .....(١٣)..... $F_g = mg$ و.....(١٤)..... تلاحظ من خلال العلاقة .....(١٥).....أن القوة والتسارع .....(١٦)..... إلى أسفل, و أن .....(١٧).....وزن الجسم يساوي كتلتة .....(١٨).....في التسارع الذي يكتسبة .....(١٩).....للسقوط الحر. ومن .....(٢٠).....أن تدرك أن قوة .....(٢١).....الأرضية تؤثر في الجسم .....(٢٢).....لو لم يسقط سقوطا .....(٢٣)..... هذه النتيجة صحيحة على .....(٢٤)..... , وعلى أي كوكب .....(٢٥)..... بالرغم من أن مقدار .....(٢٦)..... يختلف على الكواكب الأخرى .....(٢٧).....بسبب أن قيمة g .....(٢٨)..... سطح القمر أقل كثيرا .....(٢٩)..... قيمتها على سطح الأرض.....(٣٠)..... فأن وزن رواد الفضاء .....(٣١)..... سطح القمر يصبح أقل .....(٣٢).....منه على سطح الأرض.....(٣٣)..... أن كتلتهم لم تتغير.

.....(٣٤).....تحتوي بعض الموازين المنزلية .....(٣٥)..... نوابض , وعندما تقف .....(٣٦)..... الميزان يؤثر فيك بقوة .....(٣٧)..... أعلى لأنك تلامسة. و.....(٣٨)..... لا تتسارع فإن القوة.....(٣٩)..... المؤثرة فيك تساوي صفرا. .....(٤٠).....هذا يعني أن قوة .....(٤١)..... F_{sp} التي تدفعك إلى .....(٤٢)..... تساوي مقدار قوة وزنك .....(٤٣).....التي تؤثر فيك إلى.....(٤٤)..... كما هو مبين في.....(٤٥)..... (٤-٧)وتحدد قراءة.....(٤٦).....بواسطة القوة التي تؤثر.....(٤٧)..... نوابضه فيك. لذا فإن .....(٤٨)..... يقيسه الميزان المنزلي هو .....(٤٩)..... , و لسهولة التحويل بين.....(٥٠)..... و الوزن فإن الميزان يدرج بحيث يعطينا الكتلة. أما إذا كنت على كوكب آخر فإن مقدار انضغاط النابض سيختلف, وستكون قراءته مختلفة. تذكر أن الكيلوجرام هو الوحدة الدولية للتعبير عن الكتلة, ولأن الوزن قوة فإن الوحدة الدولية المستخدمة للتعبير عنه هي النيوتن.

الأهداف
- تصف العلاقة بين وزن الجسم وكتلته.
- تقارن بين الوزن الحقيقي والوزن الظاهري.

المفردات
الوزن الظاهري
القوة المعيقة
السرعة الحدية

الشكل 4-6 القوة المحصلة المؤثرة في الكرة هي قوة الوزن F_g.

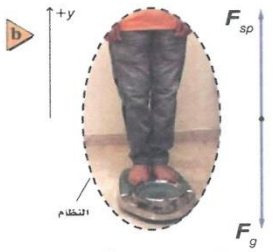


$F_{\text{محصلة}} = ma$

$F_{\text{محصلة}} = F_g, a = g$

لذا يكون $F_g = ma$

الشكل 4-7
a. إن قوة النابض التي تؤثر إلى أعلى في الميزان المنزلي تساوي مقدار قوة وزنك عندما تقف فوقه.
b. يبين مخطط الجسم الحر أن النظام متزن لأن قوة النابض تساوي وزنك.



Appendix 2

Using Newton's Second Law [1]

Look carefully at **both** [2] of these models: the visual and the **physical** [3] models of a ball falling freely **in** [4] Figure 4-6. What are the bodies **which** [5] affect the ball? As long **as** [6] the ball falls without touching **anything** [7] the gravity of the air is **negated** [8]. So the only affecting [9] force is F_g. **Where** [10] the acceleration of the ball is **g** [11] (as mentioned in the **third** [12] chapter), then Newton's Second Law **becomes** [13] F_g = mg. Perhaps **you** [14] will notice that the **aforementioned** [15] relationship between the force and the acceleration is **exerted** [16] downwards. The **amount** [17] of the weight of the body equals the solid mass **multiplied** [18] by the acceleration, which increases the speed as a **result** [19] of falling freely. It is **necessary** [20] to recognize the earth's **gravity** [21] force that influences the body **even** [22] if it doesn't fall **freely** [23].

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 3.

Appendix 3

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' (*maʿṭūf, 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 (*laʿla, hatta*).

Gap No.	Deleted word الكلمة	Trans-literation	Translation	Part of speech موقعها في الجملة	Transliteration of part of speech	Technical or semi-technical
(1)	**Law**	**_**	[in English, i.e. Newton's Second Law]	_	**noun**	semi-technical
(2)	كلاً	**kullan**	both	مفعول به	**mafʿūl bih** (object)	non
(3)	الفيزيائي	**al-fiziyāʾī**	physical	معطوف	**maʿṭūf** (noun)	technical
(4)	في	**fy**	in	حرف جر	**ḥarf jar** (preposition)	non
(5)	التي	**al-laty**	which	صفة	**ṣifah** (adjective)	non
(6)	ان	**anna**	that	حرْف ناسخ	**ḥarf nāsikh** (particle)	non
(7)	شيئ	**shayʾ**	thing	مضاف إليه	**muḍāf īlaih** (genitive)	non
(8)	مهملة	**muhmalah**	negated	خبر إنَّ	**khabar īnna** (predicate of īnna)	non
(9)	تؤثر	**tuʾathir**	affect	فعل مضارع	**fiʿl muḍāriʿ** (present verb)	semi-technical
(10)	حيث	**ḥaythu**	where	ظرف مكان	**ẓarf makān** (adverb of place)	non
(11)	**g**	-	[Eng. symbol: 'gravity']	-	[symbol]	technical
(12)	الثالث	**al-thālith**	third	صفة	**ṣifah** (adjective)	non
(13)	يصبح	**ywṣbiḥ**	becomes	فعل مضارع	**fiʿl muḍāriʿ**	non

					(present verb)	
(14)	**لعلك**	**laʿlaka**	perhaps you	**لعل :حرف ناسخ ك :ضمير**	**ḥarf nāsikh** (particle) **+ ḍamīr** (pronoun)	non
(15)	**السابقة**	**al-sābiqah**	previous	**صفة**	**ṣifah** (adjective)	non
(16)	**يؤثران**	**yu'athirān**	exert an effect	**فعل مضارع**	**fiʿl muḍāriʿ** (present verb)	semi-technical
(17)	**مقدار**	**miqdār**	the amount	**اسم إنَّ**	**īsm īnna** (noun)	semi-technical
(18)	**مضروبة**	**maḍrūbah**	multiplied by	**حال**	**ḥāl** (adverb)	semi-technical
(19)	**نتيجةً**	**natījatan**	as a result	**مفعول لاجله**	**mafʿūl li ājlih** (obj. of causation)	semi-technical
(20)	**الضروري**	**al-ḍarūri**	necessary	**اسم مجرور**	**īsm majrūr** (noun)	non
(21)	**الجاذبية**	**al-jāthibīyah**	gravity	**مضاف إليه**	**muḍāf ilaih** (genitive)	technical
(22)	**حتى**	**ḥatta**	even	**حرف (ابتداء)**	**ḥarf ībtidā** (particle)	non
(23)	**حرًا**	**ḥurran**	free	**صفة**	**ṣifah** (adjective)	semi-technical
(24)	**الأرض**	**al-ardh**	the earth	**اسم مجرور**	**īsm majrūr** (noun)	semi-technical
(25)	**آخر**	**ākhar**	another	**صفة**	**ṣifah** (adjective)	non
(26)	**g**	-	[Eng. symbol: 'gravity']	-	[symbol]	technical
(27)	**و**	**wa**	and	**حرف (ابتداء)**	**ḥarf ībtidā** (particle)	non
(28)	**على**	**ʿlā**	on	**حرف جر**	**ḥarf jar** (preposition)	non
(29)	**من**	**min**	from	**حرف جر**	**ḥarf jar** (preposition)	non
(30)	**لذا**	**lithā**	so	**ل : حرف جر وتعليل ذا : اسم إشارة**	**ḥarf jar** (preposition) **+ īsm ishārah** (demonstrative)	non
(31)	**على**	**ʿlā**	on	**حرف جر**	**ḥarf jar** (preposition)	non
(32)	**كثيراً**	**kathīran**	much	**تمييز**	**tamīz** (noun)	non
(33)	**الرغم**	**al-raghm**	although	**اسم مجرور**	**īsm majrūr** (noun)	non

(34)	**الموازين**	**al-mawāzīn**	scales	**مبتدأ**	**mubtada** (noun)	technical
(35)	**على**	**ʿlā**	on	**حرف جر**	**ḥarf jar** (preposition)	non
(36)	**على**	**ʿlā**	on	**حرف جر**	**ḥarf jar** (preposition**)**	non
(37)	**إلى**	**ilā**	to	**حرف جر**	**ḥarf jar** (preposition)	non
(38)	**لأنك**	**liʾānnaka**	because you	**ل : حرف جر وتعليل حرف إنَّ : ناسخ ك : ضمير**	**ḥarf jar** (preposition) + **harf nāsikh** (particle) + **ḍamīr** (pronoun)	non
(39)	**المحصلة**	**al-muhāsilah**	outcome	**صفة**	**ṣifah** (adjective)	semi-technical
(40)	**و**	**wa**	and	**حرف (ابتداء)**	**ḥarf ībtidā** (particle)	non
(41)	**النابض**	**al-nābiḍ**	spring	**مضاف إليه**	**muḍāf ilaih** (genitive)	technical
(42)	**أعلى**	**aʿlā**	up	**اسم مجرور**	**īsm majrūr** (noun)	non
(43)	**Fg**	**_**	[Eng. symbol: 'force of gravity']	_	[symbol]	technical
(44)	**أسفل**	**asfal**	downward	**اسم مجرور**	**īsm majrūr** (noun)	non
(45)	**الشكل**	**al-shakl**	figure	**اسم مجرور**	**īsm majrūr** (noun)	semi-technical
(46)	**الميزان**	**al-mīzān**	scale	**مضاف إليه**	**muḍāf ilaih** (genitive)	technical
(47)	**بها**	**biha**	by	**بـــ : حرف جر هَـــا : ضَمِير**	**ḥarf jar** (preposition) + **ḍamīr** (pronoun)	non
(48)	**ما**	**ma**	which	**اسم إنَّ**	**īsm īnna** (noun)	non
(49)	**الوزن**	**al-wazn**	weight	**خبر**	**khabar** (noun)	semi-technical
(50)	**الكتلة**	**al-kutlah**	mass	**مضاف إليه**	**muḍāf ilaih** (genitive)	technical

Appendix 4 *Mean student conceptual score by nationality*

Nationality	**Mean conceptual total (/50)**	**No. of students**	**Arabic as L1?**	***Group Mean***	***Group No.***
Saudi	16.03	223	Yes		
Yemeni	18.92	39	Yes		
Jordanian	21.57	7	Yes		
Egyptian	21.42	19	Yes		
Syria	19.72	18	Yes		
Palestinian	18.59	22	Yes		
Sudan	20.94	17	Yes	*17.37*	*345*
Pakistani	7.25	4	No		
Somalia	14.50	2	No		
Eritrea	14.25	4	No		
Chad	12.00	1	No		
Turkistan	24.00	1	No		
Afghan	19.00	3	No	*13.87*	*15*
Overall	17.22	360	-	*17.22*	*360*

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 5 *Mean student conceptual score by age*

Age	**Mean conceptual total (/50)**	**No.**
14	14.00	1
15	18.93	115
16	17.13	206
17	13.71	32
18	6.50	4
19	.00	1
Missing	13.00	1
Overall	17.22	360

Appendix 6 *Students' difficulties with specific language features*

Category	**No of items**	**Reliability Cronbach α**	**Mean % wrong**	**Std Dvn**
Noun @	**13**	**0.682**	**74.63**	**17.249**
Adjective	6	0.481	58.98	23.594
Genitive	5	0.476	52.87	27.48
Particle	4	0.484	55.00	28.16
Preposition @	**7**	**0.690**	**50.79**	**28.62**
Verb	3	0.383	45.00	32.90
Prepositional phrase	4	0.416	71.25	26.84
Symbol	3	0.164	87.96	17.68
Technical @	**9**	**0.586**	**72.99**	**17.88**
Semi-technical @	**11**	**0.582**	**68.03**	**16.85**

Non-technical [@]	**30**	**0.855**	**62.41**	**19.84**

Key: [@] N > 3, α > 0.5