Optimal Line Length for Reading Schoolbook on Screen

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Abstract:

Although experimental studies have shown a strong impact of text layout on the legibility of e- text, many digital texts appearing in eBook or the internet use different designs, so that there is no straightforward answer in the literature over which one to follow when designing e- material. Therefore, in this paper we shall focus on the text layout, particularly the influence of line length on reading performance of e-school book. An intensive experiment has been conducted which targeted school students between the age of 9 and 13. Performance of students was assessed through two dependent variables: (1) time to complete each tasks; and (2) accuracy of the answers. Accuracy data was based on the number of correct answers the students provided and the total score was 12 points. Several of findings were reported by this experiment such as; the time needed to complete all the question models becomes significantly low when students are older, errors for all the question models are expected to be significantly lower for older students. Comparing reading text on a single column with double columns shows that the reading process is affected by the students' age, as older students were faster when reading through double columns, while students aged 9 prefer the single column in both reading processes. The study has recommended double line for a faster reading among students with satisfactory reading performance, while long line was suggested for students who have difficulty with their reading.

Key words: *text layout- reading online- line length*

Introduction:

Textbook in any e-educational system is an important element that requires a closer look at its components and structure, as well as identifying the barriers that affect the level of learning. This can be achieved in different aspects such as the analysis of textual content or sentence structure which is one of the concerns of linguists. On the other hand, examining the textual content can determine the appropriateness of the education level for students. This type of assessment is part of educators' concerns and by examining and defining the factors that could affect reading a text on screen, this is usually related to the way of displaying texts

such as font size, colour, background colour, amount of text and the location of the text on the screen.

In the early stages of the e- book, designers and writers attempted to create e- book using the metaphor of a paper book, while the capabilities of e- book have led to changes in the way of reading. In the same context, Kareen Coyle (e.g.Coyle 2008) defined the reason behind failure of e- book to render the print book electronically rather than developing new standards as a guide for designers and writers to use when designing e- text. This idea was supported in many studies that examined the display of e- text (e.g. Maria dos santos Lonsdale 2006).

Usability studies have reported several elements that affect the designing of electronic text which may be summarized as follows:

- **Age of readers**: age has been reported in most usability empirical studies more than any other demographic variable as this variable has a significant effect on the legibility of e- text (e.g. Cheyne 2005; Miller and Gagne 2008).
- **Language**: applying a guideline of information design for all languages will not lead to an optimal design, e.g. comparison between English and Arabic is unfair for several reasons such as the fact that these two languages have different morphological structures (Shahreza, S et al. 2006). This may lead to differences in the principles of displaying e-texts.
- **Information resources**: the reading process differs based on the type of information resources as mentioned by many researchers, e.g. Andrew (Dillon 2001) investigated the reading process in two sources of information, journal and manual book. The survey provides clear evidence that the reading process changes according to the type of reading material. In addition, differences may occur if the same text was displayed in different media [paper version or e- version] (Abubaker and Lu 2011).

Moreover, Abubaker and Lu (2011) investigated the reading process that students follow when reading the school text book in two versions [electronic and paper version]. The survey reports that there are several scenarios used when reading a school book between the two versions; also, differences occurred in the reading process when reading e-version according to the purpose of reading or using school book. Additionally, students usually use two strategies, and each strategy requires specific tools and techniques such as highlighting the sentence, taking notes, or using a finger when reading the text.

This paper examines the effect of one of the typographical factors [line length] that was reported as a significant variable that affects legibility by examining the influence of the reading process through answering these research questions:

Q1: how long should a line of text be in terms of the optimal legibility of the online school book?

Q2: which line length is preferred by students?

Q3: how long should a column of text be when skimming or scanning an Arabic school textbook to optimal speed?

Q4: Are reading speed and error rate affected by reading strategy?

The structure of the paper is as follows. The first section introduces the related literature. The second section deals with methods and procedures. The third section provides a summary of

the findings as well as an analysis of the collected data, and the last section will draw out the main conclusions.

1. Theoretical perspective:

The line length of the text was considered to be one of several typographical factors that affected reading speed and comprehension. Line length is measured in typographic units (picas), which are used to increase or reduce the amount of space between letters. Other researchers used units of inch and centimetre, while resent studies attempted to measure line length using a totally number of characters. In addition, eye movement, reading speed and average of errors are common methods used to identify optimal line length which may explain the difference in the findings. Nanavati and Bias (2005) divided the factors affected by line length according to the analysis by several previous studies as follows: (1) subjective factors such as ease of reading and user preference and satisfaction; (2) objective factors such as comprehension and reading rate.

Looking at the related research did not provide a clear answer on this issue, upon which mix findings were reported (Nanavati and Bias 2005). For example, according to Creed et al. (1987), one column was read faster among younger readers (18-24 year olds), while there was no influence of column format on older readers (over 25 years old) and the reading rate was affected by the column format. This finding was also supported by Dyson and Kipping (1997) when they measured the effect of a three-column format on the reading rate and comprehension using texts from online magazines in which 18 participants read text in two situations (single column, about 80 characters per line; two columns; and three columns, about 25 characters per line). They also reported that comprehension was better for faster readers in the three-column page format. This means that a faster reader may be able to scan a short column easily. In the same context, Dillon et al. (Andrew Dillon 1990) measured the comprehension and reading rate on screen using different sizes of screen [20 & 60 line]. They pointed out that there was no difference in the performance of readers. According to Duchnicky and Kolers (1983), whose experiment investigated the reading speed of text on screen, a text with 80 characters were read faster than one with 40 characters.

In addition, Youngman and Scharff (1998) calculated the optimised line length to be 100 letters and is unlikely to be as long as 123 letters. On the other hand, Dyson and Haselgrove (2001) estimated that the line length with 55 characters produces better comprehension scores than the longest line in the case of multiple choice questions. This finding was rejected by Barbara et al. (Chaparro, Shaikh et al. 2005)who claimed no significant effect of text layout on comprehension performance. And when using a comparison method between screens to

measure readers' perceptions, they reported that the line length with 55 characters reads easily but were not the fastest.

Moreover, Bruijn et al. (Landoni and Diaz 2003) provide different outcomes from reading online. Based on designing two difference models, 15 inches display 60 lines and 12 inches display 23 lines. 56 participants were asked to read a "legal-sociological discourse" of around 1900 words and remember the text. They pointed out that the screen containing 23 lines were better for learning time than the one with 60 lines. Moreover, Kruk and Muter (Landoni and Gibb 2000) compared three situations, two in print and one on screen. To explore reasons for the slower reading of text from screen, the survey indicated that 40 lines were read faster than 20 lines in both print and on screen. Some researchers downplayed the significance of this study because its main focus was on the print text, and is therefore not suitable for collecting empirical evidence for reading online (Dyson 2004).

Furthermore, Yi, Park et al. (2011) surveyed the affected number of columns in the readability, comprehension and satisfaction of e-book. English is a second language for participants (22-26 year old). They were asked to read a text with 400 words (2000 to 2010 characters) and answer five questions in one minute. The survey reported that participants prefer reading one column. Table (1) summarised the main findings.

Table 1: Summary of the main recommendations of studies that focused on line length

Findings	Reference
Single or long column read faster.	(Duchnicky and Kolers 1983; Creed 1987; Dyson and Kipping 1997; Youngman and Scharff 1998; Yi, Park et al. 2011)
No influence of column format on reader over 25 year.	(Creed 1987)
No influence of column format on reader.	(Chaparro, Shaikh et al. 2005)
Short column easy to scan by faster reader.(three column)	(Dyson and Haselgrove 2001)
Long line was preferred for reading from printed material.	(Landoni and Gibb 2000)

Nanavati (Nanavati and Bias 2005) provided a guideline according to the distilled studies. The guide provides general recommendations without providing explanations that show if these principles are concerned with all the differences that affect reading the text.

On the other hand, In the Chinese language, some researchers such as Nai-Shing et al. (Nai-Shing, Jie-Li et al. 2011) reported that double columns and double line spacing are read more comfortably than the single column. While in Arabic language, there is not study that providing empirical evidence for optimal line length for reading online text.

Thus, the effect of the column format still requires more thinking so as to cover these aspects. Most of these surveys prove the effect of scrolling on reading. And they were limited to

showing just the favourite display format without providing any explanations as to why the reader prefers this and why he/she dislikes the other format. Also, could this decision be affected by the type of reading? This type of question should be asked by researchers when doing this kind of research.

2. Methodology:

2.1. Participants:

48 native Arabic students (24 male and 24 female) volunteered for this experiment. The participants' age ranged from 9 to 13. They all used the computer and internet. Participants were divided into two groups and each group read from the same text (as seen in table 2).

Table 2: the size of the sample.

Gender	One column	Two column	Total
Female	12	12	24
Male	12	12	24

2.2. Material design:

The instructional module interface was designed for experimenting using Microsoft's expression web software. Each test had two different interfaces. Each web text module was designed in light of the recommendations given in the literature. The text selected from the school book was mainly used for learning purposes and students used several reading strategies that require a unique technique when seeking information; thus, a type of questions was used to measure the effect of line length on reading speed, comprehension and satisfaction.

A total of 19 Arabic sentences were used in the experiment. The length of the text was between 8 and 12 lines, the number of words per line in one column was between 22 [104 characters] (as seen in Figure 1), while in two columns between 8 and 11 [37 to 39] (as seen in Figure 2). All the sentences were extracted from a lesson in the Libyan schoolbook. The lessons had no extremely rare words, such as names of people or exotic places, technical terms or unusual mechanisms. Table (3) shows the attributes of the experiment and the observed elements.

Table 3: show the basic observed elements.

Attributes	Observed elements	Applied to interface
Body text	**Font size, line length, colour of text.**	**Black font+ right alignment+ two and single column+ ….. Words. Words per a line.**
Background	**colour**	**Light grey**
margin	**Larger than 2.5 inches.**	
Type of question	**Information recall and reading faster.**	**Multi choices, open questions and true and false.**

Figure 1: The experiment interface for text display in a long line.

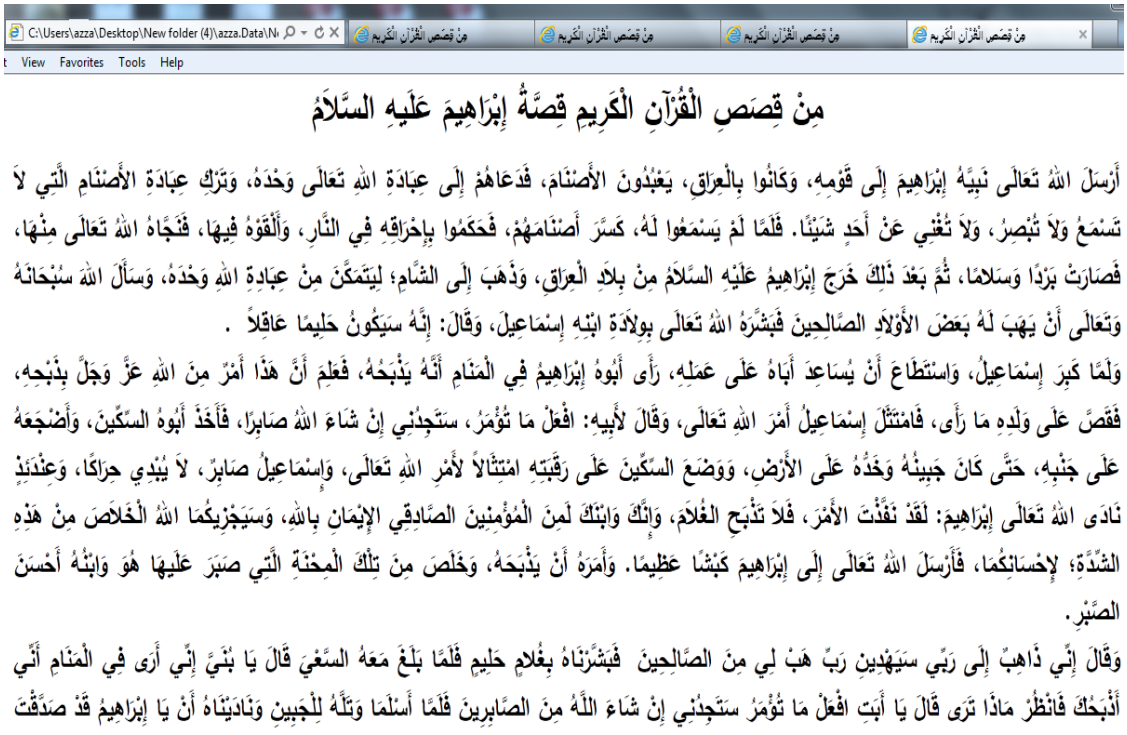
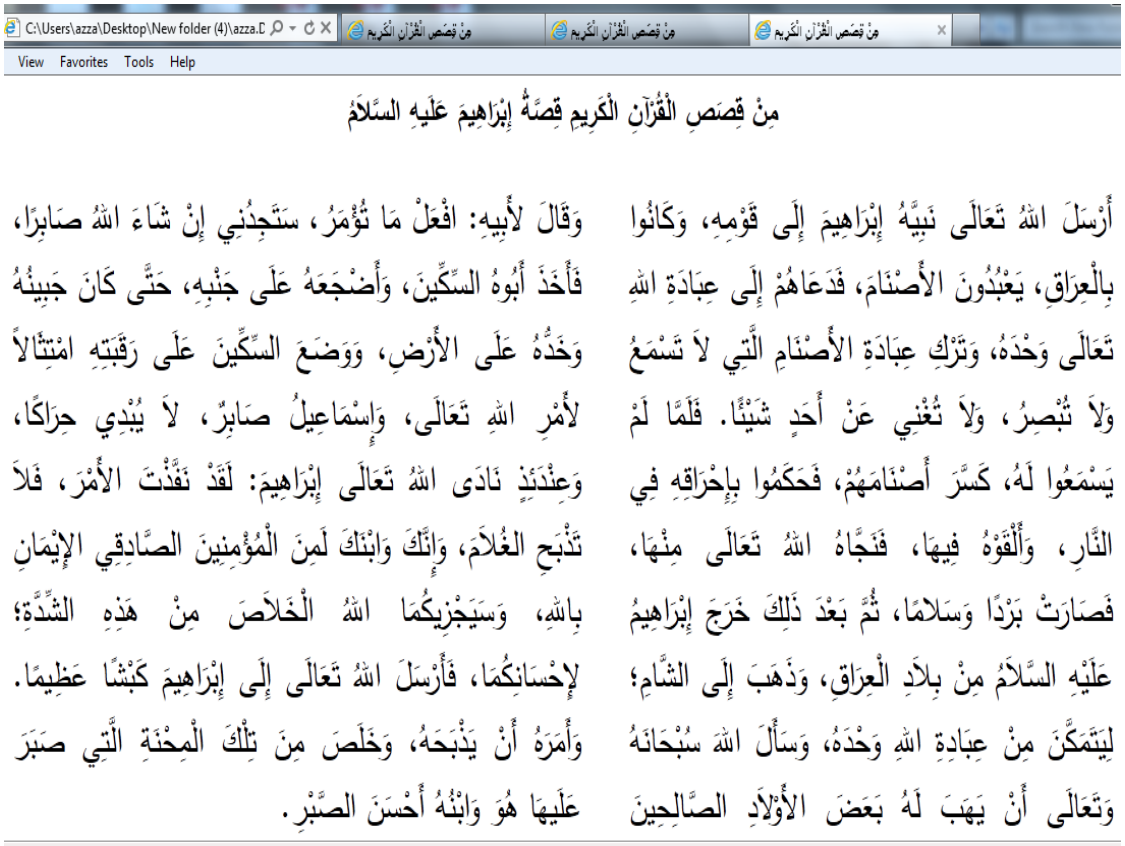


Figure 2: : The experiment interface for text display in a short line.



2.3. Procedure:

Each participant was seated in a closed room environment facing the laptop. Participants all used the same PH Pavilion dv6 [Intel i5 core processors] laptop, with the choice of using a mouse attached peripherally. The screen size of the laptop was 15.6 inches with display setting of 1366 x 768 pixels. Internet Explorer 6.0 was used as the browser environment to present the test software and task. Because of the age of the students, the observer sat behind the participants to record time and encourages them to continue with the experiment and take notes. Participants scanned the tasks in two conditions [one column, two columns] in looking for answers to 12 questions [4 open questions/ 4 true or false questions/ 4 multi answer questions].

Performance was assessed through two dependent variables: (1) time to complete each tasks; and (2) accuracy of the answers. Accuracy data was based on the number of correct answers the students provided and the total score was 12 points. In this experiment, satisfaction was measured as a dependent variable using the questionnaire. The questionnaire has 8 questions with response as yes or no or no difference. The satisfaction questions relate to how easy it was to read the text or recall information in it. In addition, disorientation is expected to measure user perceptions towards ease of searching the lesson, becoming lost in the text, and being comfortable with the text layout.

3. Data analysis and discussion:

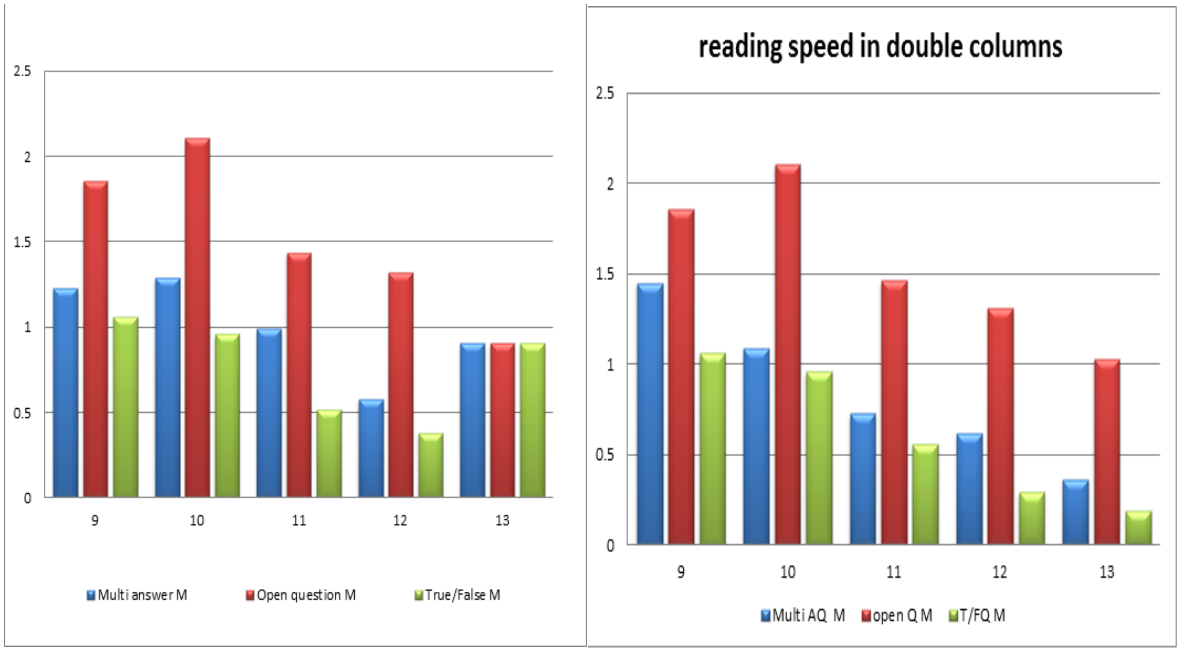
3.1. Reading times:

Reading times were measured for the best line length in each reading strategy, i.e. skimming or scanning. The collected data show that the computed time seems to decrease as long as students' age increases when reading through single and double columns. This finding is to be expected since age in the early stage of education affects the reading speed. Otherwise, students tend to show a different speed when answering the three types of questions. For example, the comparison between the mean reading speed to answer multi answer question [MAQ] from reading text on a single column with double columns shows that the reading process is affected by the students' age, as older students were faster when reading through double columns, while students aged 9 prefer the single column in both reading processes. In addition, the mean reading time of students aged 13, 12 and 11 when reading a single column was [.905, .575, and .988] respectively, while in the double columns it was [.360, .614, and .723] in the same order. Thus, students who read the entire text searching for specific word prefer to use a double column, e.g. the mean reading speed of the entire text by older students [13 years old] was less when reading the text in a double column [MAQ/ M= .360 and T/FQ/ M .185] and [MAQ/ M= .905 and T/FQ/ M= .905] than in double columns, as can be seen in Table (4) and figure (3).

Table 4: The average reading time for three different types of questions in two different line-lengths according to the reader's age

		Single column						Double column					
		Multi A		Open Q		T/F Q		Multi A		Open Q		T/F Q	
Age		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
9	Speed	1.226	.153	1.857	.445	1.061	.074	1.446	.338	1.858	.445	1.061	.0742
10	Speed	1.29	.157	2.105	.469	.957	.294	1.083	.165	2.105	.469	.957	.294
11	speed	.988	.325	1.432	.343	.514	.271	.723	.314	1.461	.346	.555	.313
12	speed	.575	.230	1.317	.298	.378	.363	.614	.235	1.305	.129	.290	.075
13	speed	.905	.905	.905	0	.905	0	.360	0	1.030	0	.185	0
Kruskal-Wallis test		Chi=10.601 p-value=.014		Chi=5.430 p-value=.066		Chi=9.292 p-value=.010		Chi= 11.443 p-value=.010		Chi= 7.703 p-value=.053		Chi= 13.193 p-value=.004	

Figure 3 : presenting a mean for testing three types of questions and reading through single and double columns



The reading level of students, as defined by the teacher, was considered as an independent variable. The collected data shows that the reading speed of students with a low-level of reading was less when reading a single column according to the mean reading time (m = .921,1.643, .726) as presented in tables 5 and 6 and Figure (4). Students prefer long line because they can see a whole sentence in the same line but they face difficulty when dealing with a sentence that is broken up into two lines. Thus, displaying a complete sentence in one line is preferred by students compared to displaying it in a short or long line. In addition, short line was preferred by students with a high level of reading. This finding is in line with the findings of Dyson and Haselgrove (2001). For the multi answer model, it seems that students with low level need more time when reading a short line than those with a high level, even though according to the median test where Z=1.89 with p-value=.068, the preference is statistically not accepted. The same pattern is observed for the open question model, but this

difference in median between both levels is statistically significant. No obvious difference in the True/false model between the two levels needs to be mentioned. This finding confirms that reading speed is influenced by the reading strategy used by the reader.

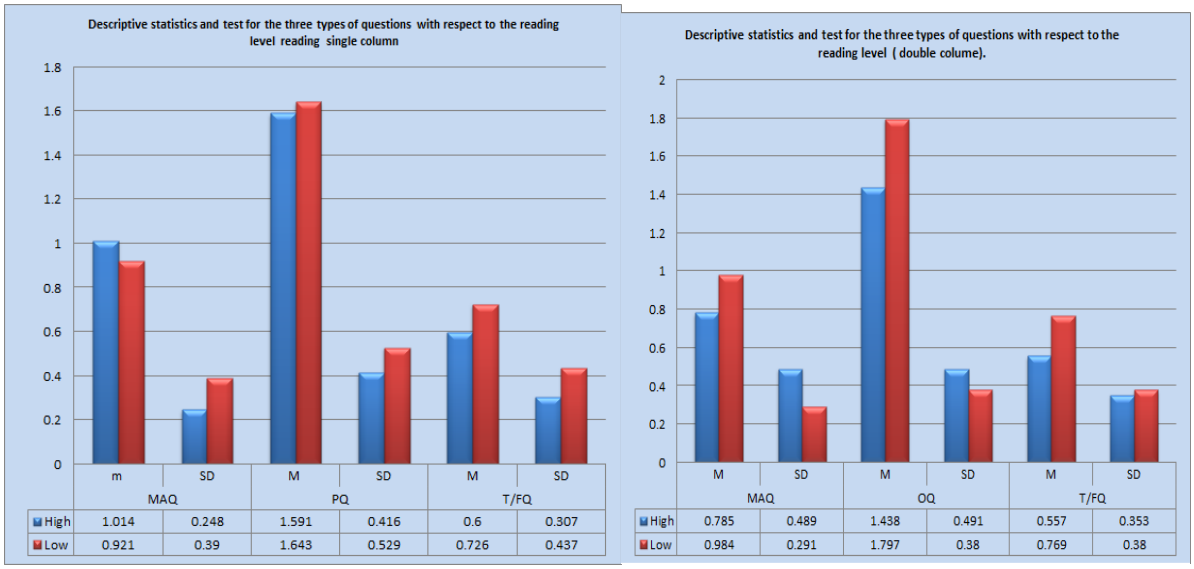
Table 5: Descriptive statistics and test for the three types of questions with respect to the reading level (single column).

Reading level		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
High	Speed	.515	1.380	1.014	.248	1.220	2.390	1.591	.416	.280	1.115	.600	.307
Low	Speed	.360	1.365	.921	.390	.795	2.380	1.643	.529	.180	1.220	.726	.437
Mann-Whitney	Speed	Z=-.231 p-value=.817				Z=-.231 p-value=.817				Z= -.433 p-value=.665			

Table 6: Descriptive statistics and test for the three types of questions with respect to the reading level (double columns).

Reading level		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
High	Speed	.300	1.950	.785	.489	.795	2.390	1.438	.491	.180	1.115	.557	.353
Low	Speed	.555	1.310	.984	.291	1.315	2.380	1.797	.380	.280	1.220	.769	.380
Mann-Whitney	Speed	Z= -1.89 p-value=.068				Z= -2.309 p-value=.020				Z= -1.357 p-value=.178			

Figure 4: The average reading time for three different types of questions in two different line-lengths according to the reading level.



The number of studies which considered gender as a strong demographic variable that influences information behaviour (e.g. Hupfer and Detlor 2006; Liu and Huang 2007). Little difference in mean time was reported by testing differences in responses to question models due to gender. When looking at the differences in responses to the question models between genders reading short line, male and female tend to show very little difference in descriptive statistics. Based on average speed, males are somewhat better than females with regard to the multi answer and true/false questions, whereas females are better with regard to the open question. The Mann-Whitney test does not find any significant difference, and hence both

males and females are expected to share more or less the same level of performance, see Table (7 and 8) and Figure (5).

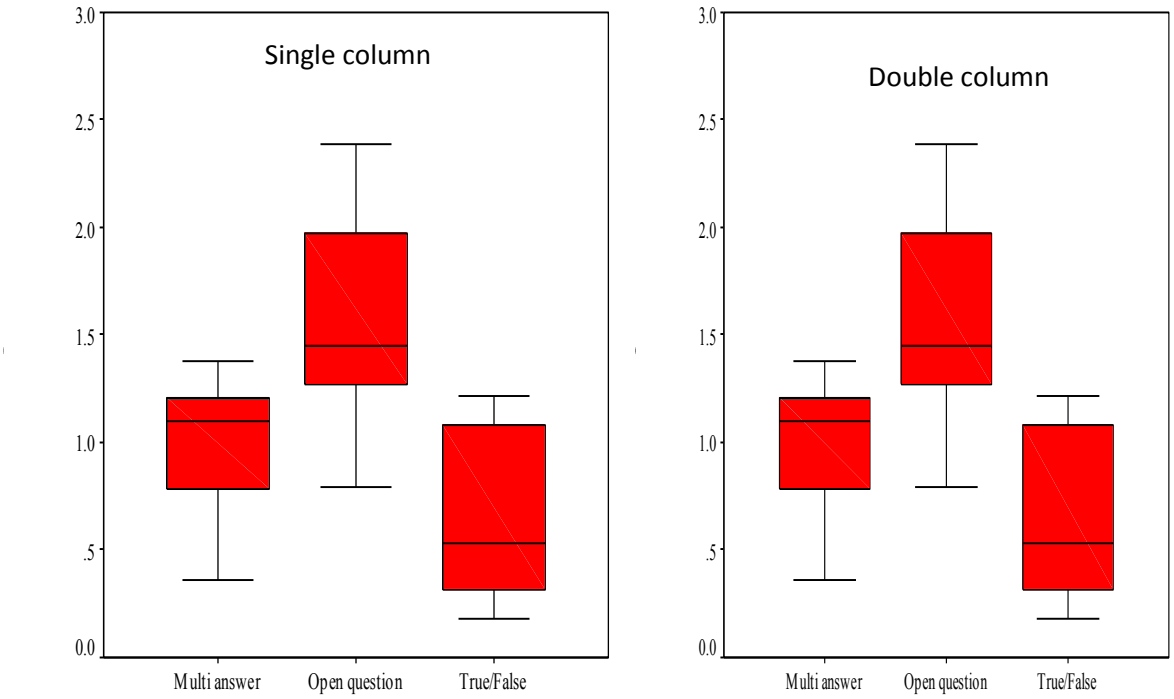
Table 7: The average reading time for three different types of questions in two different line-lengths according to gender (single column).

Gender		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
Male	**Speed**	.415	1.380	.991	.354	.795	2.390	1.712	.551	.180	1.140	.619	.359
Female	**Speed**	.360	1.305	.944	.304	1.030	2.170	1.515	.359	.185	1.220	.707	.401
Mann-Whitney	**Speed**	Z= -.577 p-value=.564				Z= -.924 p-value=.356				Z= -.404 p-value=.686			

Table 8: The average reading time for three different types of questions in two different line-lengths according to gender (double column).

Gender		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
Male	**Speed**	.375	1.310	.877	.356	.795	2.390	1.712	.552	.180	1.140	.619	.359
Female	**Speed**	.300	1.950	.895	.466	1.030	2.170	1.515	.358	.185	1.220	.708	.400
Mann-Whitney	**Speed**	Z= -.173 p-value=.887				Z= -.924 p-value=.378				Z= -.404 p-value=.713			

Figure 5: Boxplot for speed using the three question models in two different line-lengths according to gender.



3.2. Accuracy of reading:

The errors made for the question models are measured to define optimal line length for the sake of obtaining a high level of comprehensibility. Descriptive statistics and test for the three types of questions in Table (9) and Figure (6) show that the error rate decreases as age

increases, where it becomes .875 for age 12 compared to 1.446 for age 9. The chi-test is 9.126 with p-value=.028, indicating a significant difference. This finding supported a line of thought considered by several of researchers such as Cheyne (2005) as well as Salmerón and García (2011).

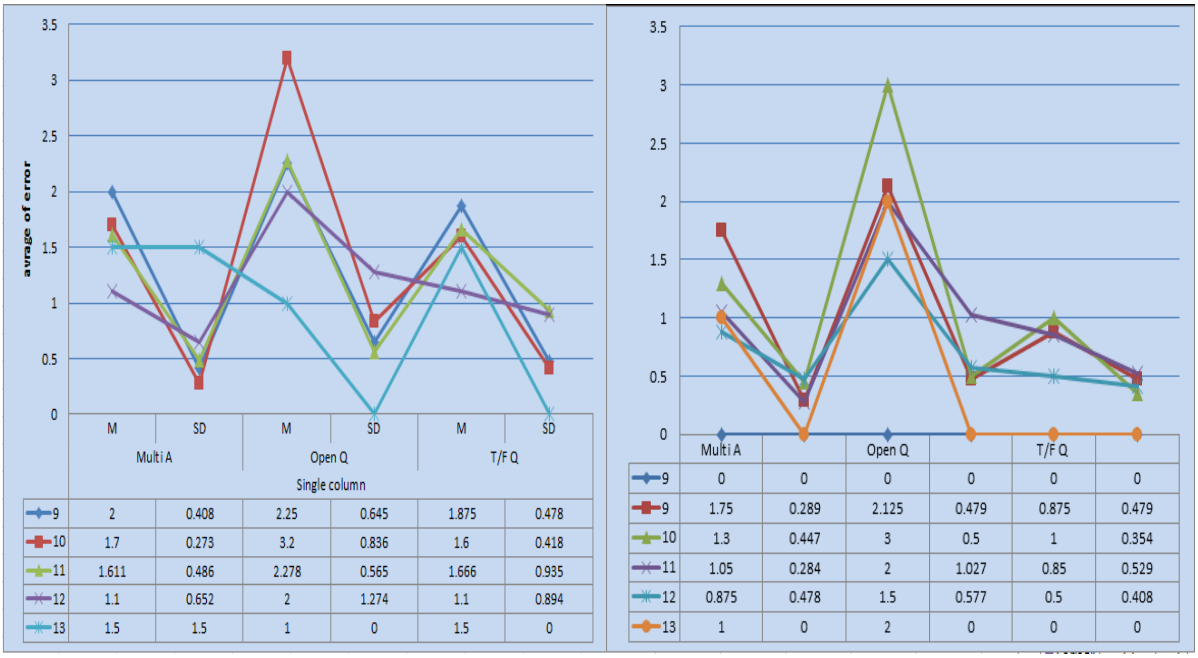
In addition, the number of errors becomes higher for the second type of question (OQ), which requires reading a whole paragraph to access the answer. According to the chi-test which is 7.266 with p-value=.064, ages do not reduce the error resulting from the open question. It is noted that the error consistency within each age is low. In terms of the true/false question, the error drops as age goes up. Despite this difference, the chi-test is reported to be not significant. The lowest is zero for ages 11 and 12. In addition, the average error for these ages is similar but varies from age 9 to 10, and hence the Chi-square= 13.193 with p-value=.004 (highly significant).

Moreover, the average error in a single column becomes .575 for aged 12 compared to 1.446 for aged 9. The chi-square is 5.673 with p-value=.129, meaning that the difference is not significant. The number of errors looks higher for the second model of questions. According to the value of chi-square which is 5.567 with p-value=.135, ages do not have any effect on the differences in errors resulting from the open question model. It is noted that the error consistency within each age group is low. For true/false question model, the errors go down as age goes up. The chi-square (which is 2.283) is reported to be not significant (p-value=.516). The lowest error found is zero for aged 12 while the highest is 3 for aged 11. While comparing the mean of error in single and double column shows differences in students' preference, where the double column was preferred by students of all ages, several explanations are provided to explain this. Some students aged 9 to 10 prefer short line because they can move easily from line to line searching for a specific word or information, while older students can scan the whole page to get a general idea which helps in finding more than one answer at the same time. Additionally, when the eye is fixed on the short line, the latter is higher compared to the long line. Some of the older students find the short line easier to scan and for moving from sentence to sentence.

Table 9: Descriptive statistics and test for the three types of questions with respect to age reading through single and double column.

Age		Single column						Double column					
		Multi A		Open Q		T/F Q		Multi A		Open Q		T/F Q	
		M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
9	Error	**2.000**	**.408**	**2.250**	**.645**	**1.875**	**.478**	**1.750**	**.289**	**2.125**	**.479**	**.875**	**.479**
10	Error	**1.700**	**.273**	**3.200**	**.836**	**1.600**	**.418**	**1.300**	**.447**	**3.000**	**.500**	**1.000**	**.354**
11	Error	**1.611**	**.486**	**2.278**	**.565**	**1.666**	**.935**	**1.050**	**.284**	**2.000**	**1.027**	**.850**	**.529**
12	Error	**1.100**	**.652**	**2.000**	**1.274**	**1.100**	**.894**	**.875**	**.478**	**1.500**	**.577**	**.500**	**.408**
13	Error	**1.500**	**1.500**	**1.000**	**0**	**1.500**	**0**	**1.000**	**0**	**2.000**	**0**	**.000**	**0**
		Chi=5.673 p-value=.129		Chi=5.567 p-value=.135		Chi=2.283 p-value=.516		**Chi= 9.126 p-value=.028**		**Chi= 7.266 p-value=.064**		**Chi= 2.697 p-value=.441**	

Figure 6: show mean (M) and standard deviation (SD) of average of errors in single and double column according students' age.



On the other hand, the outcomes of analysing reading level are demonstrated in Table (10 and 11) for reading long and short lines. The Mann-Whitney test does not detect any significant difference for all the question models. In addition, little improvement was reported when reading text in short line by students with a low level of reading. The mean reading time to answer true and false question type [T/FQ] decreased from .600 min in single column to .557 min when reading a short line. In addition, significant difference in the mean reading time was reported when answering multi answer choices [MAC] (M= .785) from reading short lines, whereas the mean time for answering the same type of question from reading long lines was 1.014 min which is high.

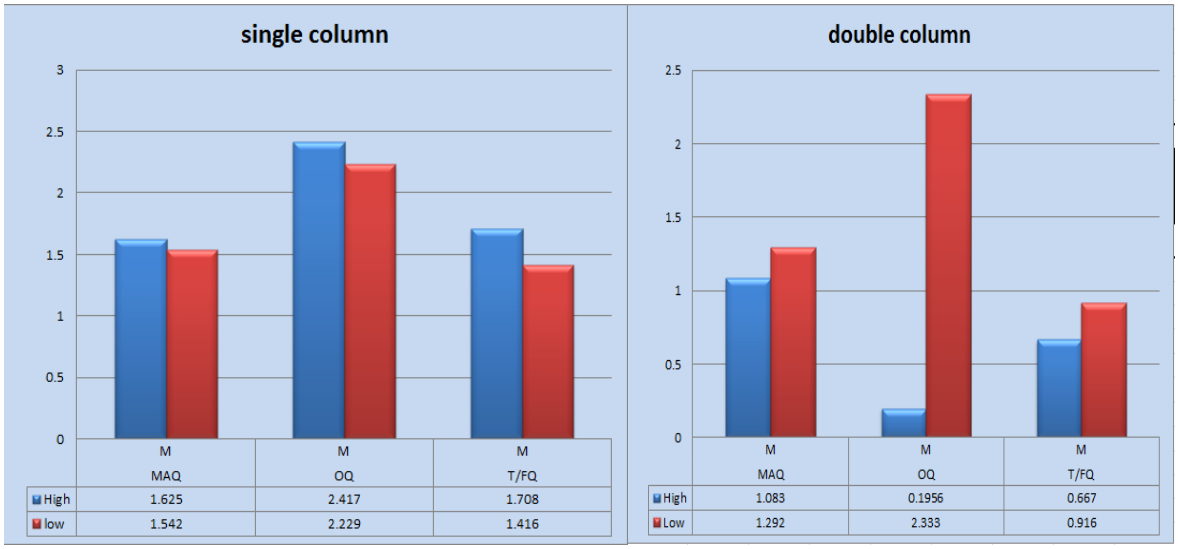
Table 10: The average reading error for three different types of questions for single column according to the reader's reading level.

Reading level		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
High	**Error**	.500	2.500	1.625	.569	1.000	4.500	2.417	.925	.500	3.00	1.708	.722
low	**Error**	.500	2.000	1.542	.498	.500	4.00	2.229	.940	.000	2.500	1.416	.793
Mann-Whitney	**Error**	Z=-.213 p-value=.831				Z=-.088 p-value=.930				Z= -.853 p-value=.394			

Table 11: The average reading error for three different types of questions for single column according to the reader's reading level.

Reading level		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
High	**Error**	.500	1.500	1.083	.358	.500	3.500	.1956	.988	.000	1.500	.667	.443
Low	**Error**	.500	2.000	1.292	.498	1.000	3.500	2.333	.748	.000	1.500	.916	.515
Mann-Whitney	**Error**	Z= -.936 p-value=.410				Z= -1.055 p-value=.319				Z= -1.208 p-value=.266			

Figure 7: The average reading error for three different types of questions in two different line-lengths according to the reading level.



The errors made in all the models do not differ significantly between males and females as shown by the Mann-Whitney test in tables 12 and 13. In general, performance in terms of finishing the answer due to gender is regarded as very similar. Also, males and females have the same error scores in all the question models. The error rate for both male and female decreased from T/FQ [M= 1.375] in single column to [M= 0.75] in double column. Comparing students' performance in two different line lengths shows that the double column was the best for both male and female. Although some researchers such as Hupfer and Detlor (2006) as well as Liu and Huang (2007) reported differences in the information behaviour for the reader according to gender, our finding has rejected it.

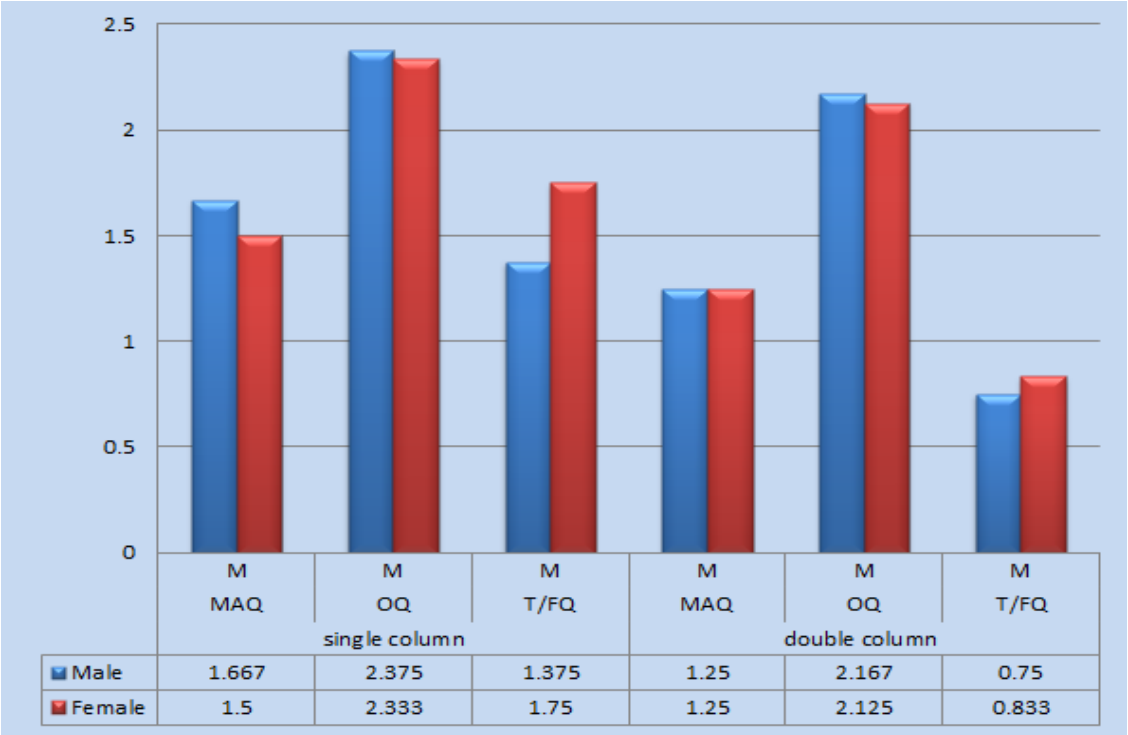
Table 12: Descriptive statistics and test for the three types of questions with respect to gender reading through single column.

Gender		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
Male	**Error**	1.000	2.500	1.667	.492	.500	4.500	2.375	1.068	.500	3.000	1.375	.772
Female	**Error**	.500	2.500	1.500	.564	1.000	4.000	2.333	.778	.000	2.500	1.750	.723
	Error	Z= -.730 p-value=.466				Z= -.117 p-value=.907				Z= -1.530 p-value=.126			

Table 13: Descriptive statistics and test for the three types of questions with respect to gender reading through double columns.

Gender		Multi answer				Open question				True/False			
		Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
Male	**Error**	.500	2.00	1.250	.452	.500	3.50	2.167	.985	.000	1.500	.750	.452
Female	**Error**	.500	2.00	1.250	.433	1.000	3.500	2.125	.801	.000	1.500	.833	.536
Mann-Whitney	**Error**	Z= -.655 p-value=.551				Z= -.176 p-value=.887				Z= -.483 p-value=.671			

Figure 8: The average reading error for three different types of questions in two different line-lengths according to the reader's gender.



With respect to the errors in single column, the open question model shows the highest error, followed by the multi answer and true/false models, while the chi-square test is 9.379 with p-value <.009, which is a confirmation of highly significant differences between the errors of the three models. The Wilcoxon test proves that the errors in true/false questions are significantly smaller than the remaining models, and errors in multi answer questions are significantly smaller than the open question models. However, it seems interesting to discover that no significant difference is found between the multi-answer and true/false model.

Table 14: Pairs comparison using the Wilcoxon test in terms of speed and errors.

	Speed			error		
	Multi-answer-Open question	**Multi-answer-True/False**	**Open question-True/False**	**Multi-answer-Open question**	**Multi-answer-True/False**	**Open question-True/False**
Z	-4.296	-3.915	-4.286	-3.165	.000	-3.041
p-value	<.001	<.001	<.001	.002	1.000	.002

Finally, Table 15 provides a summary of several recommendations from analysing collected statistical data through current experiments, which could be used as a guideline when designing academic Arabic online text for students aged 9 to 13. The reading strategy was considered as a strongly affected variable for selecting the perfect line length according to the reading speed. In addition, the readers' age and reading level has a significant influence on the human information process. For instance, the study has recommended double line for fast reading for students whose reading performance is satisfactory. However, long line is suggested for students with difficulty in reading.

Table 15: optimal line length to read school book on screen according to reading strategy.

Age	Reading strategy		Reading level	Reading strategy		Gender	Reading strategy	
	Scan	Skim		Scan	Skim		Scan	Skim
9	Single line	No difference	High	Single line	Single line	Male	No difference	No difference
10	Single line	No difference						
11	Double line	Single line	Low	Double line	Double line	Female	No difference	No difference
12	Double line	Double line						
13	Double line	Single line						

4. Conclusion:

According to the literature, defining the optimal line length for reading online academic texts by children using the Arabic script is still without a satisfactory answer. The majority of studies merely recommended design guidelines for displaying texts on screen in terms of line length without providing any explanation for their ability to apply it to different applications of reading. Thus, in this study, we were mainly focused on the effect of the reading process on line length; our expectation was that the effects of the reading process on line length during reading would depend on the readers' age, reading level, and gender. The findings of this study support this point, wherein age and reading strategy were reported as two independent variables that strongly affected defining optimal line length for displaying Arabic script for children. Although there were no significant differences in reading speed between students of the same age, significant differences were noted in reading speed and error rate in terms of different line lengths according to the readers' age.

Furthermore, younger students showed better reading performance when scanning a long line. However, they preferred lines with 35 to 37 words when reading to understand. Students aged 9 to 10 discover that with a single line it is comfortable to move from line to line, even while assisting them to search for more than one answer at the same time. Moreover, there was no significant change in reading performances between male and female students. The study has recommended double line for fast reading for students whose reading performance is satisfactory, while the long line is suggested for students with difficulty in reading.

Finally, it is difficult to pinpoint a more complete finding that can be considered standard for displaying academic texts on screen. From these findings, however, it has become clear that students' reading strategy and information behaviour may have to do with differences in line length.

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