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The Effect of Visual Interface Design on Text Readability in Web-Based Learning Application

Zuriana Abu Bakar and Phillip D. Long
Software Technology Research Group (Softech), School of Informatics and Applied Mathematics,
University Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

Abstract: Usability is a well-known area in Human-Computer Interaction (HCI) research. Usability has been the main concept for capturing the "quality of use" of interactive systems which involves the efficiency and effectiveness. On the other hand, in the millennium age, web-based learning becomes an essential educational medium to transfer skills, information and knowledge. The transformation of learning platforms from conventional learning to web-based learning has changed the presentation of the learning documents, whereby from paper-based materials to digital materials on the web. The way information is presented on the printed and web-based documents is different. In web-based documents, the information (content) and the content presentation are both essential and should cooperate with each other in the web-based documents. However, the attention paid to the presentation of information specifically, the readability of the text in web-based learning platform has been limited. Not many studies have addressed this problem where readability is one of the most critical elements in competition with printed material. Thus, for this reason, this study intends to investigate the impacts of visual design of interface on student's reading text in the web-based learning context. This study took a quantitative research approach that involved experiments to collect the data. The finding of this study found that both types of interface (static interface and dynamic interface) were not able to affect the readability of learning material.

Key words: Human-computer interaction, usability, readability, visual interface design, web-based learning, finding

INTRODUCTION

At the beginning of Human-Computer Interaction (HCI) research, pragmatic issues such as the utility and usability of technical systems dominated the research area (Nielsen, 1993). The usability concept was originally expressed through the slogan "easy to learn, easy to use" which was associated with the two main usability components in interactive systems, namely, efficiency and effectiveness (Dix *et al*., 2004; Thuring and Mahike, 2007) and sometimes included satisfaction as well. However, usability is no longer automatically the dominant concern in HCI, particularly in interface design. Nevertheless, usability remains important with frustrating experiences of difficult to use digital technologies still commonplace.

The rapid development of the world wide web has led to more people accessing information on the screen and an increase in the volume of material that can be read directly from a web-based platform. Readability is a crucial aspect of web usability and could affect the success of a website (Hussain *et al*., 2012). Good readability of webpages enables readers to extract the information more easily while poor readability could impede the information extraction.

In developing web-based applications, it is important to balance the usability and user experience aspects in particular, the visual design interface. Through numerous studies in human-computer interaction, usability has become a well-established area and it remains applicable in today's applications. The transformation of learning platforms from conventional learning to web-based learning has made a difference in presenting learning documents whereby the presentation of the learning documents has transformed from paper-based materials to digital materials on the web. This scenario has impacted on student's speed of reading. However, a few studies have been done in the readability aspect because it is considered as less important factor in web-based learning. Hence, to address this issue, the visual design of interface

Corresponding Author: Phillip D. Long, Software Technology Research Group (Softech),
School of Informatics and Applied Mathematics, University Malaysia Terengganu,
21030 Kuala Terengganu, Terengganu, Malaysia

and readability investigations are carried out in order to explore whether the visual design of interface could influence the student's reading speed for digital materials. This study attempts to answer a research question: is there any significant difference in readability measured by speed of reading text between the static and dynamic interfaces?

In this study, a static interface applies fixed formats where the visual design elements of an interface does not change and not varies. Alternatively, a dynamic interface means that the appearance of interfaces changes each time it is rendered during the interaction process between students and the application.

Literature review: The following sub-section provides a detail explanation of the study background such as usability, readability, web design and readability and visual design.

Usability: Usability is a well-known area in HCI research. The usability of a system with a certain functionality is the range and degree by which the system can be used efficiently and adequately to accomplish certain goals for certain users (Nielsen, 1994). The functionality of a system is defined by the set of actions or services that it provides to its users (Karray *et al*., 2008). In particular as Bevan (1995) stated, usability has been the main concept for capturing the "quality of use" of interactive systems which involves the efficiency and effectiveness. The system is considered to be effective when there is a proper balance between its functionality and usability (Nielsen, 1994). Consequently, the users can complete their tasks more efficiently and they feel satisfied with the performance of the website when using an effective system.

As the web became an increasingly essential interface, usability research began to focus more specifically on extending the basic usability principles into the web environment (Nielsen, 2000). Web usability studies have become the main focus among researchers due to the increased complexity of the web and the increased number of web users that make the web a complex and competitive environment. Web usability is a test of the user's success in doing some task or finding some information on the webpage (Llanos and Munoz, 2007). If users are unable to find what they need from a given webpage due to the lack of information or the complexity of the webpage design, they will become frustrated and move on to another site. This is the reason why web usability studies have grown in importance in order to ensure that the creation of a website could truly meet the needs and expectations of the online users. Thus, this study will focus on the one of the usability aspect which is readability of the text.

Web design: The web is one of the greatest inventions of the twentieth century. It is a great communications medium and interactive system in the Internet environment (Chi *et al*., 2000). With the fast growing and increasing use of the web, the web design area is becoming more important and widely recognised. Web design is important since design has the ability to influence the system or the product acceptability (Hartmann *et al*., 2008). A good user interface design encourages an easy, natural and engaging interaction between a user and a system and it permits users to perform their required tasks (Stone *et al*., 2005). In contrast, a bad or poor interface design leads to the user's frustration and dissatisfaction. Thus, it is essential to produce a good interface in order to make users more comfortable with computer systems and enable them to attain their goals with minimum frustration. The person who creates the interface of a web-based application is called the web designer (or designer). The person who uses the resulting program is called the end-user (or user) (Myers, 1995).

Designing a usable interface that is responsive to user requirements is critical and challenging to the web designer. This is because web designers need to consider usability and other design features to satisfy the user's needs (Palmer, 2002). Indeed, the code to implement the user interface typically takes up 40-90% of the code for an entire program (Chalmers, 2003). In order to design user interfaces that could satisfy the user's needs, web usability engineering which is the principles and techniques of usability engineering is applied to web design (Yan and Guo, 2010). The web usability engineering approach encompasses a user-centric design rather than a technology-centric design (Yan and Guo, 2010). User-centric web design focuses on its user, rather than the computer's input and output (Thomas and Macredie, 2002). Subsequently, to effectively meet the user's needs, at the web design stage, the designers should make essential decisions about what their user wants, what to say and how to arrange the content (Hashim, 2003). Web design involves a broad set of activities for addressing these diverse aspects including information architecture design, readability design, search design and page design (Yan and Guo, 2010). The present study focuses on page design, particularly for the interface that involves the visual design component.

Readability and visual design: Readability is defined as the property that permits an individual to read sentences from the stimulus material easily regardless of the meanings (Gradisar *et al*., 2006). Usually, readability is concerned with continuous texts (Gradisar *et al*., 2006). Junaid *et al*. stated that readability is the efficiency of reader's eyes going along with the text flow. In other words, readability refers to how comfortable it is to read a text (Karray *et al*., 2008).

Information presentation has become an important issue with the increasing use of the world wide web as people have a choice to read documents electronically through web-based platforms. The way information is presented on the printed and web-based documents is different. Nielsen (2000) highlights, the primary mistake happens if the web designers simply take content that is written for print and put it on the screen. In web-based documents, the information (content) and the content presentation are both essential and should cooperate with each other in the web-based documents. Cracken and Wolfe (2004) mention, an effective layout of the web pages that present the information could reinforce a site's content organization and the result is easy navigation. This view is supported by Robins and Holmes (2008) who found that when the same content of web page is presented using different levels of aesthetic treatment, the content with a higher aesthetic treatment was judged as having higher credibility of content. In the same way, Daly *et al*. conceded that when there is an amount of information available to users, there is a need for organizing content on a web page, so that, it is more appealing, more effective and more efficient for a user to navigate and find the desired information.

According to Junaid *et al*. font type, size and line height are the important factors in providing good readability of web pages. Different fonts can signify whimsy or gravity (Yan and Guo, 2010) and could affect the readability. Font sized at or above 10 points (Lynch and Horton, 2001) provide good readability. Also the appropriate line height is important because if the height is too small, the lines will mix together. Meanwhile, lines with large heights will make them appear separate sections. Furthermore, colour combination of text and background is an important characteristic of visual stimuli that may affect visual performance such as readability (Gradisar *et al*., 2006). Yan and Guo (2010) and Junaid *et al*. points out colour contrast could influence the readability of the web where black text on white background or white text on black background is recommended colour combination since both combinations have high contrast value. Along with the right typeface and size, line-height and the right colour contrast ensures readability on your web pages.

Table 1: Measuring reading speed in the literature

Researchers	Elements measured	Display device
Bernard *et al*. (2001)	Font type and font size	Computer screen
Bernard *et al*. (2002)	Font type and font size expanded from Bernard *et al*. (2001) by adding the number of font type and font size tested	Computer screen
Dyson and Haselgrove (2000)	Line length	Computer screen
Dyson (2004)	Line length, columns, window size and interlinear spacing	Computer screen
Shaikh (2005)	Line length	Web-based
Gradisar *et al*. (2006)	Colour combination	Web-based
Yu *et al*. (2007)	Letter spacing and visual span	Computer screen

Previous related works: This study reviews the empirical studies relevant to the areas of the current study which are readability and visual design. The aims of this section are to place the current study in the context of the extant literature and to present the proposition of this study, that is, the effect of the visual interface design on text readability in the web-based learning platform.

Initially, Thinker and Peterson (1932) in their classic study noted that the speed of reading is regarded as a good measure of readability. Further, the speed of reading correlates to the ease of reading sentences.

There are a number of design factors that affect the speed of reading on a computer screen and web-based platform. These factors include the font type and font size (Bernard *et al*., 2001), line length (Dyson and Haselgrove, 2000; Dyson, 2004; Shaikh, 2005), columns, window size and interlinear spacing, letter spacing and visual span, character spacing, line spacing, alignment, paragraph, heading, colour scheme, content presentation and colour combination (Gradisar *et al*., 2006). Table 1 provides an overview of the design elements that affect reading speeds and the methods of presenting materials in the previous studies.

The presentation of information specifically, the readability of the text is rarely treated as an important factor (Gradisar *et al*., 2006). Not many studies have addressed this problem which is especially expressed in technology-enhanced web-based systems (Latchman *et al*., 1999) where readability is one of the most critical elements in competition with printed materials. For example, Dyson (2004) conducted empirical investigations into reading speed that focused on the design factors such as line length but the materials were presented on a computer screen display and not live via a web-based platform. On the other hand, a recent study by Junaid *et al*. examined readability in the web-based context but the method implemented in that study was not discussed thoroughly for example, the materials used for

presenting the information were not precisely described. Thus, the current study aims to examine the readability aspect of the web-based context, particularly in the learning domain by focusing on the typographical element and colour combination as independent variables.

MATERIALS AND METHODS

An experimental approach has been adopted in order to examine participant's speed of reading text that presented in the web-based format. In the following sub-sections, the participants involved in the study, the measures, the materials used, the pilot study and procedure are explained.

Participants: This study involved 40 university students as the test subjects. The sample consisted of 28 females and 12 males. The range of the participant's ages was from 19-35 years. Out of the 40 participants, 3(7.5%) had used web-based learning for <1 year, 10(25.0%) had been using it for 1-2 years, 9(22.5%) had used it for 3-4 years and 18(45.0%) had used it for more than 4 years.

Measures: In this study, readability of the learning materials was measured by the speed of reading text passages. Two passages were presented by the system prototype (Visual Design Interface System-VDIS) to the participants in order to evaluate their speed of reading. A passage on the topic of cells was given for the static interface and a passage on the topic of pollution was given for the dynamic interface.

A passage about cells was allocated to the static interface and a passage on the topic of pollution was assigned to the dynamic interface. The passages were selected from the "English for Everyone" website (permission was obtained to use these instruments) and both passages were written at approximately the same reading level (similar in levels of difficulty) and discussed similar material (both dealt with science-related topics). According to Lazar *et al.* (2010), a within-group design would be appropriate as long as the text materials presented to the participants under the two conditions were different in content but similar in levels of difficulty.

In total, the cells passage consisted of 658 words and the pollution passage consisted of 707 words. Since, there were ten web pages for the static and dynamic interface stimuli, both passages had to be decomposed into ten short paragraphs to fit with the ten pages. Therefore, each page of the web pages contained a short paragraph of the passages. Although, the pages were adjusted to have approximately the same amount of words in a web page, difficulties were found in this matter. The words were divided based on the content of the passages. In other words, each web page contained one paragraph relating to particular contents of the passages. For example, the pollution passage was comprised of several types of pollution such as air, water, soil pollutions and others. One page was devoted to one type of pollution and the content for every type of pollution was approximately the same length. Thus, the range amount of words for every page in the static interface was 47-89 words. Subsequently, there were 45-86 words per page in the dynamic interface.

The time taken (in seconds) by participants to read the passages was captured by the system automatically. The system starts counting the time when the participants click the "Begin" button (to start reading the passage) at the "Instruction page". Then, the system stops counting the time when the participants click the "Quiz" button at the last page of the passage. Next, the time participants click the "Quiz" button subtracting the time when participants click the "Begin" button is noted. The difference between these times was considered as the time taken for the student to read the passages. The calculation of the time taken to read the passages is measured as shown in Eq. 1:

$$\begin{aligned}&\text{Time taken to time when participant}\\&\text{clicks the reads = "Quiz" button-time}\\&\text{when participant the passage clicks}\\&\text{the "Begin button"}\end{aligned} \quad (1)$$

Next, speed of reading was calculated by dividing the total words per passage by time taken to read each passage in seconds (Words per seconds-Wps) (Ng, 2002) as shown in Eq. 2. Then, the derived values were converted to words per minute (Wpm):

$$\text{Reading speed passage} = \frac{\text{Total numbers of words in a}}{\text{Time taken to read a passage}} \quad (2)$$

Pilot study: A pilot study was carried out prior to the real experiment to check if there were any deficiencies in the tasks that were planned for the real experiment and needing any improvements. The time taken to complete each task and the entire task was also noted in order to allocate the time participants would need for the real experiment.

The pilot study involved pre-testing the measurement instrument which is passages. Since, the measurement materials were delivered through the system, it was not a problem to amend the materials if needed. Two

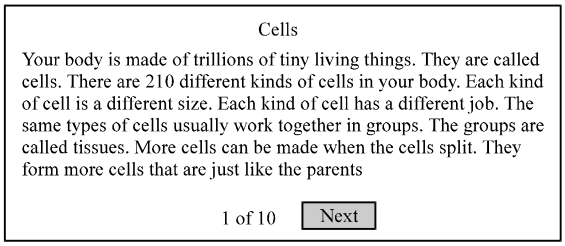

Fig. 1: Example of a stactic interface

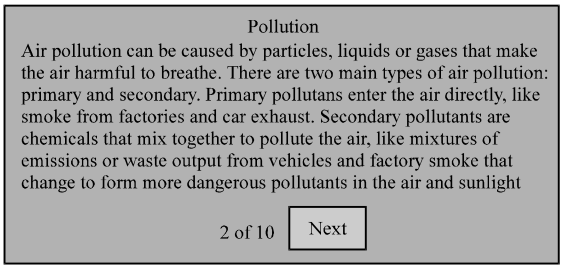

Fig. 2: Example of a dynamic interface

undergraduate students and two postgraduate students were invited to perform the pre-testing task for the instruments.

In general, the responses regarding the experiment flow indicated that the distribution of the handout materials needed some alteration in terms of the sequence of delivering handouts to the participants. The passages for the readability measurement were selected from an education website. Therefore, pre-testing of the passages was conducted to evaluate the complexity of the passages in order to ensure that both passages were suitable for the higher education student's level.

Materials: The materials in this study included the handouts (printed documents) and the stimuli (displayed using VDIS). There were two printed handouts, the first handout was a one-page information sheet and the second handout was a consent form.

In regard to the stimuli, this study consisted of two types of interface as stimuli, namely, static and dynamic interface. In this study, the static interface stimuli represented the generic content pages of web-based learning application. The static interface stimuli were generated from the design element values as follows: white background colour, black font colour, Times New Roman (TNR) font type, 16 pixels (px) font size and 110% line height. The layout designs for the static interface stimuli are depicted in Fig. 1.

On the other hand, the design elements and their values used to design the presentation layer of the dynamic interfaces are varies as describes in Table 2. Meanwhile, Fig. 2 depicts one of the layout designs for the dynamic interface stimuli in which it represents interface D3 (Table 2).

Procedure: This study explains the procedure that was followed to carry out the experiment with the participants. This study applied the repeated measure design method whereby each participant completed both static and dynamic tasks. Each subject was tested individually in an office space where they were seated at a personal

Table 2: Dynamic interfaces design elements and values

Interface	Colour combinations		Typography		
ID	Font	Background	Font type	Font size (px)	Line height (%)
A4	Black	White	TNR	19	110
A8	Black	White	Arial	19	110
D4	Green	Yellow	TNR	19	110
B3	Blue	Yellow	TNR	19	80
B7	Blue	Yellow	Arial	19	80
C6	Yellow	Red	Arial	16	110
D3	Green	Yellow	TNR	19	80
E1	Red	Green	TNR	16	80
E5	Red	Green	Arial	16	80
E3	Red	Green	TNR	19	80

computer. The entire experiment was conducted using a web-based application prototype called the Visual Design Interface System (VDIS). The researcher was available during the experiment in order to provide additional explanations of the procedure (if needed) and to administer the proper execution experimental process.

At the beginning of the experiment, the researcher explained the procedures of the testing. At the same time, the participants were also provided with the instruction task in writing and they were asked to read the instructions carefully and ask the instructor for any clarification.

Afterwards, the participants started using the VDIS for the testing purposes. The system provided instructions for the tasks but if the participants could not understand the instruction given, they could request an explanation from the researcher prior to every task.

Firstly, the participants were asked to fill in their personal information and web usage information through the system. Secondly, the VDIS directed them to the next task which was task A. Task A was devoted to the static interface (interface A). The participants were asked to read a passage (700 words) that displayed ten interfaces or pages. Each page consisted of a short text paragraph, normally around 70 words per page. The participants were not permitted to turn back to the previous pages when reading the pages. This was controlled by the system.

After task A was completed, the subjects had the opportunity to take a break to clear their mind and rest their eyes to restart focusing on the next task.

Thirdly, the participants moved to task B which was related to the dynamic interface (interface B). Similar to task A, the participants were asked to read a passage. There were ten interfaces (pages) in which the system automatically changed its interface design elements when participants move to the next pages. Once the participants completed the task B, the system directed the participants to a "thank you" page and the participants were asked to exit from the system.

RESULTS AND DISCUSSION

The results of the readability consist of the preliminary results and main results. The main results report the findings about the readability when comparing the static and dynamic interfaces.

Preliminary results: Table 3 shows the results for the normality test based on the skewness and kurtosis values for reading speed scores. It is found that there was a violation on the skewness and kurtosis values for the speed of reading data. Thus, these normality results suggest that a non-parametric test should be used for further analysis.

Main results: Based on the normality results, the Wilcoxon signed rank test was carried out to evaluate the effect of the static interface and dynamic interface on student's reading speeds. The tests found that there was no significant difference between the static interface and dynamic interface in terms of speed of reading passages.

Even though the results in Table 4 indicate that there was a relative increase in the reading speed of students who were using the dynamic interface, this difference is not significant ($z = -9.48$, $p = 0.34$ with large effect sizes ($r = 1.06$)). The median score on the speed of reading increased from the static interface (Md = 180) to the dynamic interface (Md = 191).

The impact of readability of learning materials is assessed by the student's reading speed. A comparative study was performed to assess if there was a significant difference in reading speed between participants reading the passage on the static interfaces versus the passage on the dynamic interface. The Wilcoxon signed-rank test found that the static interface and dynamic interface did not contribute a significant effect on the student's speed of reading. This finding indicates that there are no

Table 3: Skewness and kurtosis analysis of static and dynamic interfaces for readability

	Skewness		Kurtosis	
Interface	Statistic	SE	Statistic	SE
Static interface	3.739	0.374	17.029	0.733
Dynamic interface	3.553	0.374	12.434	0.733

Table 4: Comparing median reading speed scores between static and dynamic interfaces

Interface	N	Mean reading speed (Wpm)	SD	Median reading speed (Wpm)
Static interface	40	216	143.32	180
Dynamic interface	40	279	333.01	191

improvements in terms of speed of reading passages either when participants read on static interfaces or dynamic interfaces. Even though this is a difficult finding to explain, the insignificant result can be a consequence of several possible reasons. Among many possible reasons for the lack of significance in differences in readability, three that are potentially relevant to this study are: skimming the text (Dyson and Haselgrove, 2000; Berry, 2000), environmental conditions (Muter and Maurutto, 1991; Oborne and Holton, 1988) and variation between the dynamic and static interfaces that were too small.

The reason for skimming might be related to the purposes of the reading task in which the participants in this study were required to read the passages with organised and completed words. In addition, the participants were provided with multiple choice questions which most probably they could answer just by looking for the comprehensible key words. Therefore, based on these two conditions, it might be expected that the subjects just skimmed through the passages and did not read the passages thoroughly. Secondly, due to the environmental factors that could affect the subject's reading speed during the experiments such as subject's posture, distance from the screen and room illumination (Muter and Maurutto, 1991). Those aspects might influence the participant's eye vision and indirectly influence their reading performance.

CONCLUSION

To conclude, the results of this study signify that it is a challenging task for designers and educators to design educational application interface that could substantially improve an aspect of the learning experience which is the readability of learning materials. Yet this task is crucial since the effectiveness of a web-based learning environment depends on the ability of the application to provide an encouraging learning environment to students.

LIMITATIONS

Some limitations of this study should be noted and related directions for future research can be recommended. This study was unable to demonstrate significant results for the readability of learning materials. This insignificant result might be due to the participants skimming the text. Thus, it is recommended that the methods for assessing reading speed in future research should be adjusted so that the participants are required to detect letter omission or misspelled words (Bernard *et al*., 2003) or eye movements are monitored (Miyao *et al*., 1989) while subjects are reading the text. In addition, more complex questions might be considered such as the use of open-ended questions which need participants to rewrite the answers and not just choose from the pool of answers given.

SUGGESTIONS

The present study highlights the impact of the visual design interfaces on student's readability of learning materials. With respect to the readability of the learning materials, the findings indicate that both the static and dynamic interfaces did not make an optimum impact on the speed of the student's reading rate. In other words, the visual design of interfaces did not affect the readability of learning materials in a web-based learning application.

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