Usability and UX of Learning Management Systems: An Eye- Tracking Approach

Maslov, Ilia; Nikou, Shahrokh

Published in:
Proceedings - 2020 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2020

Published: 15/06/2020

Document Version
Accepted author manuscript

Document License
Publisher rights policy

Link to publication

Please cite the original version:
Maslov, I., & Nikou, S. (2020). Usability and UX of Learning Management Systems: An Eye- Tracking Approach. In *Proceedings - 2020 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2020* [9198333] (Proceedings - 2020 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2020). IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC). https://urn.fi/URN:NBN:fi-fe202201147732

Usability and UX of Learning Management Systems: An Eye-Tracking Approach

Ilia Maslov
Faculty of Social Sciences, Business and Economics
Åbo Akademi University
Turku, Finland
0000-0003-0344-4718

Shahrokh Nikou
Faculty of Social Sciences, Business and Economics
Åbo Akademi University and Stockholm University
Turku, Finland
0000-0002-0029-5852

***Abstract* —Learning Management Systems (LMSs) are widely used in higher education. Eye-tracking technology is one technology that could help objectively evaluate the influence of familiarity with an LMS on the usability and user experience (UX) of the LMS. This study utilized such technology to measure user efficiency, user effectiveness, eye-movement patterns and the quantitative area of interest (AOI) metrics of eye-movement patterns that show how fast the correct area for the task is located. Six students participated in an experiment, whereby they were asked to accomplish ten tasks in the usability testing of a popular open-source LMS called Moodle.**

The results showed that those who were familiar with the course performed about half of the tasks more efficiently and had better AOI metrics. Additionally, it was found that the participants' eye movement patterns tended to be correlated with their AOI metrics, efficiency and effectiveness of accomplishing the tasks in the usability tests. However, the correlations were not absolute. We found different eye-movement patterns among participants regarding some user interface elements, such as text hyperlinks or images.

Keywords: User Experience, Usability Testing, Information Systems, Learning Management System, Eye-Tracking

I. Introduction

The primary objective of the present study was to analyze the impact of familiarity with the content of a Learning Management System (LMS), namely a Moodle course, on the user experience (UX) of the course on the LMS. An LMS is a powerful software system that can enhance learning [1]. LMSs can be found in nearly every college and university nowadays [2]. The design of the LMS interface plays a vital role in the student–interface interaction [3], and the LMS must be designed in such a way so that users do not encounter trouble when using it [4]. As [3] reported, eye-tracking methodology could be utilized to propose improvements to the overall design of LMSs.

Product familiarity can be characterized as knowledge of the product stored in the memory acquired from direct and indirect use of the product [5]. One of the challenges of using an LMS is the initial lack of user familiarity with the system [6]. Indeed, the perceived benefits of the use of Moodle are more significant in those who have used it for a longer time [7]. One study reported how students from different admission years utilized a feature of LMS – discussion forums – differently [8]. As [9] states, some problems might occur when one is unfamiliar with the system, which may be reduced when one is familiar with the system. As such, it would be of interest to investigate the influence of familiarity with an LMS on the UX of the system among students.

Furthermore, [10] states that memory of the product usage is influential in performing an overall evaluation of the overall UX of the product. It was also stated in [10] that many users could not remember all the details of their experiences when asked to evaluate these experiences after using the product. Besides, [11] claimed that memory introduces systematic bias into an evaluation. As [12] puts it, "*the eyes do not lie. If you want to know what people are paying attention to, follow what they are looking at*". Vision measures can thus provide information about a product [13]. As mentioned by [14], eye-tracking technology is a precise and objective measurement tool to measure a user's attention during their website use. Therefore, applying eye-tracking methodology in an assessment of the usability and UX of an LMS could potentially help to eliminate the subjective bias of users, as eye-tracking is suggested to be a more precise technique than performing a survey of the users, where their responses could potentially be biased by their memories. However, few studies present a comparison of the different techniques for measuring the usability and UX of LMSs [15]. Consequently, this paper addresses this research gap by employing several techniques and comparing the results. It is also suggested that mixed methods applied in usability and UX studies supported by the eye-tracking methodology would allow improving the validity and reliability of the results via triangulation. However, as noted by [15], it may be hard to list the immediate advantages and disadvantages of utilizing eye-tracking methodology in usability and UX studies over other techniques due to the lack of such research. To address this gap, the present analysis was accomplished by performing usability testing with the help of eye-tracking equipment. Ten tasks were devised for the usability testing of the chosen LMS, with six participants involved in the usability testing, divided into two groups with three in each: those who had been exposed to the course content, and those who had not.

II. Existing Theories & Previous Work

"Web-based Information Systems", as information systems based on web technology, are requiring new approaches to be applied in the design and development of websites compared to traditional computer software [16]. A learning management system (LMS) is a powerful software system that can be used to enhance learning [1]. It provides an automated mechanism to deliver course content and to track learning progress [17]. There are two types of LMS: open- and closed-source. Open-source LMSs are generally free of charge and are customizable based on the user preferences at a low cost. Moodle is the most popular open-source LMS [18].

UX is described in [19] as a concept, which includes all facets of the user's interactions with a product: how the product is perceived, learned and used. According to [20], UX can be evaluated based on 10 facets: legal/ethical, economical, technological, emphatical, cultural, emotional, social, reciprocal, cognitive and perceptual. As [20] mentions, the perceptual facet could be represented with the vision property, which is about sight, essentially the study of visual artefacts, and could be evaluated with an eye-tracking technique.

Besides, [20] states that the cognitive facet could represent the experience of information processing and applying knowledge as a result of using the product. Finally, [20] mentions other facets of the UX that could somehow be related to the visual perception of the product, including emotional reaction, as measured by pupil dilation, and economical satisfaction, as measured by a subjective evaluation.

Also, UX changes over time (e.g. from the moment of purchase to up to one year of usage), as perceived by the sensory modalities, among which the visual senses tend to dominate, as highlighted by [21]. For example, the UX of smartphones has changed over time from the purely hedonic aspects of use towards reflecting how meaningful the product has become in users' lives. Simultaneously, even during the course of a day, the UX may be volatile. Such research underlines the importance of viewing the UX longitudinally as a function of time. Also, the importance of understanding that the UX is flexible and can change, even within the same day for the same user and the same product, is underlined in the literature [22].

III. Methods

A. Research Questions and Objectives

The purpose of this exploratory research was to analyze the effect that familiarity (the time the user has spent) with the content of an LMS has on the usability and UX of the LMS. The experiment involved usability testing employing eye-tracking equipment, with an aim to answer the following research questions (RQs):

RQ1: What are the main usability and UX properties of the LMS that are relevant among the previous participants and non-participants of the course?

RQ2: Are there any differences among the previous course participants and non-participants in terms of their perceptions on the usability and UX of the LMS?

This study is based on a comparison of the differences between two groups: participants of the course (ET) who had been using the course content for roughly two months, and students who were not participants of the course and thus were new to the course (NonET). It was thus expected that the research experiment would be more focused on exploring familiarity with the course content, since both the ET and NonET participants had used the Moodle platform before, but the NonET participants did not have prior exposure to the actual course content. However, it is recognized that there may be other variables than just familiarity with the course content that could affect the results, which might a potential limitation of the research. More detailed information regarding the participants, including the experience of their use of Moodle, is discussed later. In order to answer RQ1, the data were analyzed for both groups using the proposed usability and UX techniques in the literature. RQ2 was then answered by comparing the analyzed metrics from RQ1 between the two groups.

B. Research Models & Instruments

Techniques to study usability and UX

The holistic UX model reported in [20] was utilized to narrow down the research on the specific facets of the UX; specifically, the cognitive and perceptual facets, which are about assessing visual artefacts and the experience of processing information and applying knowledge as a result of using a product. Usability testing was also utilized and is a technique that is widely used to identify the quality of a certain area in website design. The purpose of conducting usability testing was to make sure that the students could perform the set tasks in the LMS efficiently, effectively and satisfactorily. Usability testing is a proven method that can be employed in discovering the problems students may have regarding the user interface of an LMS [23].

There are multiple techniques that can be used in research to evaluate the usability and UX of an LMS. Inquiry is the most popular type of technique and involves the use of questionnaires, focus groups or interviews. Testing is the second-most popular type of technique employed in research for measuring the usability and UX of an LMS. Performance measurement and log file analysis two of the most representative techniques used in testing. Performance measurement gathers *"quantitative data, such as task completing time and number of errors, which are collected during the test"*. Log file analysis involves an *"analysis of the logs containing collected and recorded usage data,"* such as eye-tracking data. Inspection-type techniques include heuristic evaluation, pattern-based evaluation and checklist-based evaluation. Analytic modelling is a rare type of testing, typically only utilized in the design analysis of multiple abstraction levels of UI design [15].

One of the most common techniques for usability testing is eye-tracking, which is defined as "*capturing the user's point of gaze while completing a task*" [24]. Eye-tracking and monitoring the flow of actions were proposed by [20] as potential measurements of the UX properties for perceptual and cognitive UX facets, respectively. The present research focuses on employing two techniques for testing: log file analysis (eye-tracking methodology) and performance measurement (measuring the user effectiveness and efficiency of completing the set tasks), which will be described further.

Eye-tracking methodology

Eye-tracking technology is a precise and objective measurement tool for evaluating what attracts a user's attention on a website most [14]. The hardware employed in eye-tracking can substantially reduce, if not eliminate, researcher bias and provide an instant recording of data, which thus eliminates transcription errors. In addition, it provides data that can be combined with supplemental attitudinal, behavioral or demographic data for performing a more complete analysis [25].

"Fixations" and "saccades" are terms used in eye-tracking. Fixation is a state when the eye is still over a period of time, typically from tens of milliseconds to several seconds, looking at a specific point. Fixations are the most reported events in eye-tracking assessments and are considered to measure the user attention to the point of fixation, although with some exceptions. Saccades are rapid motions of the eye from one fixation to another, taking typically 30–80 milliseconds to complete, during which the person may be considered "blind" [26].

Eye-tracking involves tracking or capturing the location of the eyes of a person while they are looking at a visual stimulus. People's eye movements can illustrate their attentional processes and can allow learning what people find important, interesting or confusing [27]. As a result of research into the UX of an LMS utilizing eye-tracking methodology, useful ideas may be generated that can contribute to design improvements [3]. Eye-tracking may also help evaluate decision-making processes, visual search efficiency, search strategies, users' expectations and narrow down some possible causes of usability issues [27].

According to [28], heat maps made from eye-tracking *"illustrate the combined gaze activity for all participants. The colors represent the number of fixations on any given area, with warmer colors indicating more fixations. Lack of color indicates areas that no one fixated on."* Besides, [28] describes a scan path as a spatial arrangement of a sequence of saccades and fixations. Both heat maps and scan paths were generated in SMI BeGaze and used in this research during the data analysis.

There are several measures of the UX of a website possible with the eye-tracking methodology depending on the task at hand. A higher number of fixations measures greater user interest in an area and the area's informativeness. Fixation duration could measure information clarity or density (the lower, the better). Layout effectiveness could be measured by the scan path complexity, the number of fixations on a display, and the time of the first fixation on the target area. The longer the scan paths and the larger the number of the fixations, the worse the effectiveness of the layout. Several visits to a display area, the percentage of users fixating on an area, and the order in which the area was first fixated are indicators of an area's prominence in display or its perceived importance [27].

Testing use effectiveness and efficiency of an LMS

The following equations were proposed by [29] for evaluating the use efficiency of an LMS.

$$user\ efficiency\ task_x = \frac{effectiveness}{\frac{t_{task}}{t_{max}}} \quad (1)$$

$$total\ user\ efficiency_x = \sum_{i=1}^{\sum tasks} user\ efficiency\ task_{x_i} \quad (2)$$

$$user\ efficiency\ intersection = \frac{\sum_{i=1}^{\sum user} efficiency_i}{number\ of\ users} \quad (3)$$

According to [29]: *"the effectiveness describes the success per task in percentage. The value t_{task} corresponds to the time the user needed for the task, and the value t_{max} corresponds to the maximum time for the task. The intersection task efficiencies result in the total user efficiency of every user. The user efficiency intersection calculates the average efficiency over all users"*. Using the average user efficiency is better since it cuts out the outliers, which may be somewhat extreme and may appear when non-average metrics are used [29]. The proposed formulas in a study by [29] could be utilized as a basis to create similar metrics for the usability testing metrics of an LMS and were considered here.

- The user effectiveness of a task is calculated as the number of correct responses given by the participants divided by the total responses given by the participants and it is measured in terms of a percentage.
- Average task effectiveness is calculated for the two groups separately and then compared with each other.
- The user efficiency of a task can be calculated by dividing the fastest possible time one can complete the task by the time it took for the user to complete the task. Thus, percentages could be formed as the measures of the user efficiency – the higher it is, the closer it is to the fastest possible time of completing the task.
- The fastest possible time of completing the task is calibrated by measuring over several trials the time it takes for the researcher to complete the task, where the researcher knows in advance where the correct answer is located on the screen. The assumption is that it is impossible to complete the task any faster than knowing where to look from the start.
- Average task efficiency was established here for each participant and for the two groups – ET and NonET – by calculating the average task efficiency for each participant and for the two study groups.

C. Experiment Set-up

Six students participated in the study and were surveyed as part of the research. The participants were divided into two groups: students from the Eye Tracking course (hereon referred to as ET) and students not from the Eye Tracking course (hereon referred to as NonET). The participants were asked to read the ten tasks and then to look at the screenshots taken from the Eye Tracking course on Moodle and to provide answers to the tasks. There were five screenshots shown to the participants, with ten task instructions given before the screenshots were shown.

A computer monitor showing the tasks to the participants was connected with the eye-tracking equipment for capturing the participants' eye movements and fixations. The size of the screen was 1920 mm x 1080 mm. The distance between the participants' eyes and the computer monitor varied from 600 mm to 720 mm. The eye-tracker SMI iView RED-m was used, and the stimulus presentation was controlled by the software SMI Experiment Center (v.3.7.60). Eye-movement data were recorded at 30 Hz. The eye-tracking data from the experiment were analyzed with the help of the software SMI BeGaze (v. 3.7.42), which allowed analyzing the heat maps and scan paths of the participants. Before the experiment started, the participants had their eye movements calibrated by asking them to fixate sequentially on nine dots on the edges of the computer screen. After calibration, the eye-gaze accuracy was verified by asking the participants to fixate on the four dots close to the centre of the screen, and the researcher judged the suitable accuracy. The accuracy of the calibration aimed at was about 1 grade. Otherwise, the participants were asked to perform the calibration again. When the experiment started, the following instructions were given to the participants:

*"In this experiment, you will be shown 10 tasks. Each task is explained in a text format, which will ask you to find something on the consequent screenshot from Moodle. When you find the answer – please ****verbally***** express it, while continuing staring at the answer, and if correct, you will be asked to proceed. If not correct, you will be asked to search again! Try to do the tasks at your normal pace, as if you were interacting with the website on your own time. Click when ready!"*

The screenshots were taken from the parts of the course "Eye Tracking Methodology in Visual Studies" at one of the universities in Finland. In the experiment, before every screenshot, a task number with the task itself was presented to the participants. Participants gave verbal answers to the tasks, additionally indicating the correct answer on the screen by pointing at it with a pencil. The researcher verified that the answer was correct, asking the test subject to continue the search on the same screenshot if the answer was wrong, while the researcher marked down the wrong answers of the participants for each of the tasks. After recording the eye movements, eye fixations and the number of incorrect answers, the participants were asked to state how long they had been using Moodle for and if they used other LMSs, as well as asked their age and gender. The participants were also asked to self-evaluate their English skills (such as reading and speaking) on a Likert scale from 1–7. Finally, the participants were asked if they had any final comments regarding the tasks; for example, if they found anything interesting they wanted to point out.

IV. Findings

A. *Descriptive Statistics*

Figure 1 represents the BeGaze data of the time (in seconds, rounded up) it took for each participant to complete the task, which was measured as the time the screenshot with the task appeared subtracted from the time the screenshot with the following text appeared. The "Control Time" is the fastest possible time of completing the task. Also, averages (Avg) for each of the groups are given under each task. The column "Sum" represents the time it took overall for each of the participants to finish the survey. The rows on the intersections of "ET Avg" and "NonET Avg" and the column "Sum" represent the average time it took for the two groups to finish the survey.

Variable	Task Number										*Sum*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
Control Time	1,3	0,9	0,9	1,1	3,0	1,3	2,7	1,1	1,3	1,3	14,9
P1	7,2	4,0	5,0	11,6	11,5	7,2	8,4	38,5	3,2	8,6	105,2
P2	9,6	21,8	5,6	17,3	52,2	8,7	18,1	6,6	6,2	6,7	153,0
P3	20,2	7,7	4,7	13,4	36,5	40,7	50,4	15,3	3,5	5,5	197,9
ET Avg	**12,3**	**11,2**	5,1	14,1	33,4	**18,9**	**25,6**	20,1	**4,3**	6,9	**152,0**
P4	18,3	19,7	5,2	33,0	12,3	27,6	141,0	20,4	7,0	3,9	288,5
P5	22,0	7,3	6,7	12,5	46,3	20,4	66,5	27,4	11,5	4,5	225,4
P6	97,7	37,1	4,8	6,8	30,6	84,8	35,9	9,9	10,1	4,0	321,7
NonET Avg	**46,0**	**21,4**	5,6	17,4	29,8	**44,3**	**81,2**	19,2	**9,6**	4,1	**278,5**

Fig. 1. The times taken for completion of the tasks

The participants provided additional information, such as their age, gender, length of time of using Moodle and English skills self-evaluation. All the participants from the NonET group and P1 from the ET group stated that they had been using Moodle for four months, but that they had also used another LMS for 2–5 years. P2 and P3 from the ET group had experience of using Moodle for 1.5 years and 2 years, respectively. Hence, while the participants in the NonET group were less experienced using Moodle, they had experience of using other LMSs. All the participants were aged between 22–24 years old. Their English skills were self-evaluated on a Likert scale from 1 to 7, where 1 is very low and 7 is a native user. The mean score for the ET group was 5.6, while for the NonET group, it was 4.3. This shows that both groups evaluated themselves as being capable of understanding English, although those in the ET group ranked themselves higher in this regard. Wrong answers were recorded for each of the participants and subsequently analyzed as part of the user effectiveness consideration. Participants were also invited to add any comments regarding anything that they found particularly interesting concerning the experiment. P1 had used another system other than Moodle before. P2 mentioned that the task answers in the text were hard to locate; while the separate elements were easy to find. P3 stated that some tasks were easy and familiar (such as links to Grades or Forums), because these were on every Moodle course page. At the same time, P3 was surveyed without glasses. Thus, he found the tasks somewhat more difficult. P6 stated that the tasks at the beginning of the experiment were difficult, and if those tasks had been easier (e.g. locate Grades), he would have understood the tasks better by learning by example. Participants P4 and P5 stated they had no further comments.

B. *Data Analysis*

Figures 2 and 3 present the two tables with the calculations of the effectiveness and the efficiency of each participant, averages (Avg) for the tasks and total average for completing all the tasks for each group (row ET Avg and row NonET Avg and column Average for the groups ET and NonET, respectively).

Name	User Effectiveness										Average
	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Task 10	
P1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
P2	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
P3	100,0%	100,0%	100,0%	100,0%	50,0%	100,0%	100,0%	50,0%	100,0%	100,0%	90,0%
ET Avg	**100,0%**	**100,0%**	100,0%	100,0%	**83,3%**	**100,0%**	**100,0%**	**83,3%**	100,0%	100,0%	**96,7%**
P4	100,0%	33,3%	100,0%	100,0%	100,0%	100,0%	25,0%	100,0%	100,0%	100,0%	85,8%
P5	100,0%	100,0%	100,0%	100,0%	33,3%	100,0%	25,0%	100,0%	100,0%	100,0%	85,8%
P6	50,0%	100,0%	100,0%	100,0%	50,0%	50,0%	50,0%	100,0%	100,0%	100,0%	80,0%
NonET Avg	**83,3%**	**77,8%**	100,0%	100,0%	**61,1%**	**83,3%**	**33,3%**	**100,0%**	100,0%	100,0%	**83,9%**

Fig. 2. Effectiveness (accuracy) of the users in responding to the tasks.

Name	User Efficiency										Average
	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Task 10	
P1	17,5%	22,8%	17,8%	9,5%	25,7%	17,4%	32,5%	2,9%	41,5%	15,1%	20,3%
P2	13,1%	4,2%	15,6%	6,4%	5,7%	14,3%	15,1%	17,1%	21,6%	19,3%	13,2%
P3	6,3%	11,8%	18,8%	8,2%	8,1%	3,1%	5,4%	7,4%	38,4%	23,7%	13,1%
ET Avg	**12,3%**	**12,9%**	17,4%	8,0%	13,2%	**11,6%**	**17,7%**	9,1%	**33,8%**	**19,4%**	**15,5%**
P4	6,9%	4,6%	16,9%	3,3%	24,1%	4,5%	1,9%	5,5%	19,3%	32,9%	12,0%
P5	5,7%	12,5%	13,1%	8,8%	6,4%	6,1%	4,1%	4,1%	11,7%	29,0%	10,2%
P6	1,3%	2,5%	18,4%	16,3%	9,7%	1,5%	7,6%	11,4%	13,3%	32,6%	11,5%
NonET Avg	**4,6%**	**6,6%**	16,2%	9,5%	13,4%	**4,0%**	**4,6%**	7,0%	**14,7%**	**31,5%**	**11,2%**

Fig. 3. Efficiency (speed) of the users in responding to the tasks.

Bases on the results, it is possible to conclude that in terms of user effectiveness, there were significant differences (more than 5%) for Tasks 1, 2, 5, 6, 7 and 8. In terms of user efficiency, there were differences in Tasks 1, 2, 6, 7, 9 and 10. On average, those in the ET group performed better than those in the NonET group based on the two measures (with an exception in user effectiveness in Task 8 and user efficiency for Task 10).

The Area of Interest (so-called AOI) is an acknowledged metric in the eye-tracking methodology. AOIs are areas of the UI (e.g. a Website Logo or a paragraph) pre-defined by the researcher. There were 6 to 11 AOIs identified in each screenshot, depending on the number of UI elements in the screenshot. The following AOI metrics were recorded: dwell time (how long the participants were looking at the AOI), sequence (how many other AOIs the participant fixated on before), entry time (when did the participant have a first fixation on the AOI), revisits (number of fixations of all participants from the group divided by the number of participants from the group), average fixation (how long each of the groups' fixations lasted in the AOI), length of the first fixation on the AOI and fixation count (how many fixations there were in the AOI). Metrics (calculated as averages of the group) that concern the Correct Areas (where the correct answer to the task was located) for all 10 tasks are shown in Figure 4. Data represented there indicate that across the AOI metrics, the ET group tended to perform better (a lower number in the metric is considered better, for example ET had a lower dwell time), although in some tasks the participants in the NonET group performed better.

	Dwell time [s]			Sequence			Entry time [s]			Revisits			Avg fixation [s]			First fixation [s]			Fixation count		
Correct Area	*ET*	*Non ET*	*Diff*	*ET*	*Non ET*	*Diff*	*ET*	*Non ET*	*Diff*	*ET*	*Non ET*	*Diff*	*ET*	*Non ET*	*Diff*	*ET*	*Non ET*	*Diff*	*ET*	*Non ET*	*Diff*
Task 1	1.4	4	-2.6	6	6	0	8.1	12	-3.5	1	3.7	-2.7	0.6	1.1	-0.5	0.3	1.3	-1	2.7	7.3	-4.6
Task 2	2.1	2.5	-0.5	3	5	-2	1.7	9.9	-8.2	1.7	1	0.7	0.7	0.7	0	0.9	0.7	0.3	3.3	3.7	-0.4
Task 3	1.3	2.8	-1.5	4	3	1	1.4	1.6	-0.2	1	0.3	0.7	0.4	1	-0.6	0.6	0.9	-0.3	2	3	-1
Task 4	4	6.6	-2.6	7	5	2	8.3	5.2	3.1	1.7	2.3	-0.6	0.3	0.3	-0.1	0.2	0.2	0	13	17	-3.4
Task 5	7.9	9.3	-1.4	5	4	1	4.3	1.9	2.4	5.3	3	2.3	0.3	0.3	-0	0.2	0.3	-0	23	27	-4
Task 6	1.4	2.8	-1.4	3	6	-3	2.7	5.6	-2.9	2	2.3	-0.3	0.4	0.4	0	0.3	0.4	-0	4	8	-4
Task 7	14	23	-8.8	3	5	-2	1.3	5.8	-4.5	7	11	-4.3	0.3	0.3	-0	0.2	0.2	0	44	66	-23
Task 8	1.2	3.6	-2.4	8	10	-2	20	8	12	1.5	4	-2.5	0.4	0.5	-0.1	0.5	0.3	0.3	2.3	7.3	-5
Task 9	1.7	3.1	-1.4	4	4	0	1.5	3.4	-1.9	0.3	2.3	-2	0.5	0.5	-0	0.4	0.4	0	3.3	6	-2.7
Task 10	2.4	1.9	0.5	5	2	3	3.2	0.5	2.7	0.7	0.7	0	1.3	0.6	0.7	1.1	0.5	0.6	2.3	3	-0.7
Average	3.8	6	-2.2	4.8	5	-0.2	5.3	5.3	-0.1	2.2	3.1	-0.9	0.5	0.6	-0.1	0.5	0.5	-0	10	15	-4.8

Fig. 4. AOI metrics for the Correct Areas

In the following section, the data are analyzed using the eye-tracking software, where patterns related to eye fixations, heat maps and scan paths are analyzed. Due to the strict space limitations, we only illustrate the eye movement patterns of Task 1 in the figure.

1) Task 1. Find and show on the screen, the day until which the eye-tracking lab will be available.

The pattern was that the ET group participants started with the paragraph above the part containing the correct answer and then checked the answer. However, some participants in the ET group carried on reading other parts. The participants in the NonET group read the text in more detail, starting from the paragraphs in the upper part of the screenshot. Then, the NonET group participants fixated on the paragraphs and other visual elements below, with the second paragraph briefly scanned in-between. However, the third paragraph was scanned only briefly in the left-most part of it, without reading further, after which the first paragraph was briefly scanned. Then, the NonET group participants returned to the second paragraph, where the correct answer was present. One participant from the NonET group said he forgot what he was searching for, asking for a reminder. Figure 5 shows an example of the eye movement patterns in Task 1.

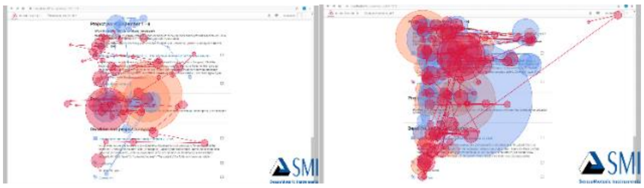

Fig. 5. Eye movement patterns for ET (left) and NonET (right) in Task 1.

2) Task 2: Find and show the link to download the "Consent" form.

Both groups showed approximately similar patterns in how they looked for the Consent link, although those in the ET group read fewer paragraphs than those in the NonET group – the content (paragraph texts) was read more extensively by the NonET group. Blue links were checked in-between reading the paragraphs by both.

3) Task 3: Find and show the link to go to the "Forums".

Both groups performed equally well, quickly locating the Forums link, starting almost immediately from the centre of the screen and switching to the left side of the screen, where the navigation menu was placed in most of the courses in that LMS.

4) Task 4: Find and show the link in case of having problems locating the building.

Both groups had similar patterns. First, both fixated on the navigation menu on the left where the "Forums" link was. ET then fixated on the hyperlinks, and read the paragraph text, close to the correct answer. The NonET group participants also started with where the "Forums" link was (except for one participant), then checked the hyperlinks in the upper part of the screenshot, and then progressed to reading a paragraph below. The hyperlinks in the upper-middle part of the content were structured: these refer to the course content, and both groups spent little time on looking at them, fixating mostly on the upper two hyperlinks. Some of the participants from the two groups also fixated on the header of the content, where the website logo and language settings were located.

5) Task 5: Find and show the example of the query of the previous research.

Both groups displayed similar patterns in searching for the correct answer. Links were checked, although the NonET group frequently provided wrong answers (referring to the "Excel_Example" hyperlink). "PREVIOUS RESEARCH" as a title was frequently fixated upon for a long time. After fixating, the participants progressed onto fixating on the text after the title "PREVIOUS RESEARCH." Sometimes the NonET group participants fixated on other paragraphs (including hyperlinks) to find the information. The ET group followed a very similar scan path as described for NonET, but spent less time reading the text.

6) Task 6: Find and show the room number of Fred's new office.

The ET group, excluding one participant who fixated on the paragraph below, checked the upper part of the screenshot where the room numbers were. The participants fixated on the correct position of the answer several times before changing fixations to other places and then returning to the correct answer. Some ET group participants fixated on the correct answer several times before progressing to other areas of the screenshot and then finally returning to the correct answer. The NonET group fixated longer on other areas of the screenshot, such as the paragraphs. Some NonET participants read the content in more depth, although following a similar pattern as the other NonET group members.

7) Task 7: Find and show where the link will be sent for the course evaluation.

Overall, the search patterns were similar for both groups, although the NonET group's fixations were more spread out, whereas the ET group was more focused on the area surrounding the correct answer. The ET group started from the upper part, scanned it briefly, and then proceeded to the paragraph containing the right answer; sometimes going lower in the same area, but then returning to the correct answer. The NonET group, on the other hand, spent more initial time looking in the upper part of the screenshot (not relevant to the answer), scanning it more thoroughly, although somehow reading just the left part of the text. Then, they progressed downward, where the answer was present. The NonET group participants also fixated on the area with the correct answer more extensively, focusing more broadly on all of the areas; while the ET group focused on the paragraph where the correct answer was presented. Besides, the NonET group participants returned to previous parts (although not fixating on them extensively, before returning to the area where the correct answer was). The NonET also fixated on elements in the header that were irrelevant to the answer (i.e. name of the profile, website logo and language settings), though they fixated on these elements only after some extended time trying to locate the answer in the text.

8) Task 8: Find and show the help button to explain what "Your Progress" means.

Both groups showed similar patterns, albeit slightly different in that the NonET group fixated on elements in the header (i.e. language settings, profile). Both fixated on the elements of the interface, fixating on the buttons, only briefly passing the text in the middle. Three areas (left, right and upper part of the screenshots) were the areas of most interest. All the participants fixated on the correct position on the screen (where the button is) for some time and then fixated on other areas before fixating on the button again.

9) Task 9: Find and show the year when the coursebook was published in paperback.

The ET group fixated on the centre of the screen, where the correct answer was, although sometimes briefly fixating on the coursebook cover image, but paying more attention to the italics sentence near the book in the middle, where the correct answer area was. The NonET group fixated for a longer time looking at the coursebook cover image, especially in the areas where the title and authors of the book were printed. The NonET group also sometimes fixated on the side elements, but after these fixations, they returned to the area of the correct answer.

10) Task 10: Find and show the link to go to the grades of the course.

The NonET group was quite fast at locating the element, starting from the middle, then sometimes fixating back to the middle part of the screenshot, until fixating on the correct place in the left part of the screenshot. The ET group followed a similar pattern, although spending slightly more time in other areas of the screenshot: right side (calendar buttons), middle-up part (welcoming to the course text), and finally in the left part, where the participants fixated on other areas of the navigation menu.

V. Discussion

There may be some specific patterns that the participants followed when completing the tasks by interacting with the User Interface (UI). Figure 6 below presents a tabulated summarization of the analysis of the eye movement patterns, user effectiveness and user efficiency.

Task	Eye Tracking Patterns	Efficiency	Effectiveness
1	NonET was reading paragraphs more in-depth than ET.	ET	ET
2	ET had similar patterns with NonET in terms of reading content, but the content were scanned-through faster than NonET. Both were checking blue text (ie, "Hyperlinks").	ET	ET
3	Similar patterns - both started in the middle of the screen and swiftly started gazing on the left side of the screen.	No Diff.	No Diff.
4	Both had similar patterns. Started with the location where "Forums" are, then scanned "Hyperlinks", then started reading paragraph with the correct answer	No Diff.	No Diff.
5	Similar patterns: switching between reading content and scanning "Hyperlinks". Both fixated on the word "PREVIOUS RESEARCH".	No Diff.	ET
6	ET focused on the correct area of the answer. NonET scanned the whole content more thoroughly (including checking other places of the text before giving the answer).	ET	ET
7	ET focused on the correct area of the answer. NonET scanned the whole content more thoroughly (including checking other places of the text before giving the answer).	ET	ET
8	Similar patterns. Both looked at navigation menu on the left, calendar on the right, upper part (above the book image). Both before giving the right answer scanned other areas and then returned to the correct answer.	No Diff.	NonET
9	NonET spent more time looking at the image of the book cover (as well as navigation menu and calendar) than did ET.	ET	No Diff.
10	NonET focused on the correct area from the start. ET spent slightly more time looking at other elements of the screenshot.	NonET	No Diff.

Fig. 6. Differences in the eye-tracking patterns, user efficiency and effectiveness, denoting which group performed better.

According to the time it took to complete the tasks, on average Tasks 1, 2, 6, 7 and 9 were completed faster by the ET group, while the survey overall was completed on average almost twice as fast by the ET group than by the NonET group. The NonET group only performed better in Tasks 8 and 10. There were also some differences found in the heat maps and scan paths of the participants in the two groups. Generally, the tasks that were completed faster were also the tasks that had different heat maps and scan paths between the two groups, whereas tasks with the same completion times had similar patterns as captured by the eye-tracking equipment.

Additionally, the simple tasks (such as locating the link to the Forums or the Grades), as characterized by the participants in the post-survey comments, were somehow easier to locate, as measured by the user efficiency and user effectiveness. Potentially, the LMS's UI elements could be classified into "visible" (easily found) or "non-visible" (not easily found). Visible elements are those that are found rapidly with few mistakes, and those are more likely to be, as based on the research, separate standout elements, such as a logo. Those elements are also referred to more frequently than non-visible elements. For the latter group of design elements (non-visible), it is possible for text information to be related to them that demands the user to read and go through the text.

In Task 4 (locate the link in terms of having troubles locating the building), both the ET and NonET group participants predominantly focused their fixation on the header (logo, language settings, profile), on the navigation menu on the left, as well as on the blue sentences, which serve as denominations of hyperlinks. Both participant groups did not read all of the hyperlinks – they did not scan through all of the links that were referring to the academic articles, reading just a few articles in the beginning, before switching their fixations from that area to other areas. Furthermore, in Task 9, the participants were asked to locate the publishing year of the book. Hence, in Task 9, both groups focused on the central part of the website, where the content was presented (image and text), which may have been judged by the participants as the place where such a piece of information would be located. It may be that the participants somehow predominantly focused on the areas where they expected to find the answer to the questions, especially the "practical area" (such as the navigation menus) and "course content area" (such as academic articles). Hence, for the question referring to the "practical area" content (locating the building), the users referred to the areas that they identified as "practical areas" first (navigation menu), skipping the content that was deemed to be for the "course content area" (academic articles).

Some tasks showed similar eye movement patterns, but efficiency and effectiveness were greater for the ET group in general. This could be related to the higher reading speed or the advantage of one group being more familiar with the content. The ET group could have performed better because of the information they already knew, which was more frequently referred to by the ET group (e.g. the day until which the lab was available). On the other hand, tasks containing irrelevant or not very noticeable information (such as the example query of the previous research) were not referred to by the previous participants. Thus, it was probably new information, just as it was for the NonET group, and hence the similar searching patterns could have existed because of that. One potential idea for practical application is that such cross-comparison between experienced and inexperienced user groups could show how much a particular place of the website is referred to by experienced users if they were faster in locating this information. For example, an area containing information regarding the published year of the book was better found by the ET group than the NonET group. At the same time, the example of the previous research query was found equally not very fast by both groups. Thus, the published year of the book was a piece of information to which the ET course participants referred to more often than the example in the previous query.

Furthermore, Figure 7 shows a comparison of the performance in AOI metrics for finding correct areas (where the answer to the task is located). Better performance in an AOI metric is considered if one group performed with a metric that was lower (e.g. less time dwelling, a smaller number of fixations). It is suggested that a smaller number of the metric correspond to a faster reaction time (faster awareness that the area is correct) or a faster fixation on the correct area, which corresponded to a faster performance. A comparison across the AOI metrics showed that the ET group tended to perform better in terms of the dwell time and fixation count, whereas in other metrics, both groups showed approximately similar performance. One could also observe that if in a task the ET group performed better for user efficiency and effectiveness, then the ET group also tended to perform better in AOI metrics for the same task. Contrary, if the NonET group performed better or there was no difference, then in terms of the AOI metrics there was either no difference or the NonET group performed better more often. Interestingly, there was no one to one correlation, as even though there were similar eye movement patterns and no difference in usability testing metrics for Tasks 3 and 4, the ET group still tended to have better performance in about half of the AOI metrics.

Task	Dwell time [s]	Sequence	Entry time [s]	Revisits	Avg fixation [s]	First fixation [s]	Fixation count
1	ET	No Diff	ET	ET	ET	ET	ET
2	ET	ET	ET	NonET	NonET	NonET	ET
3	ET	NonET	No Diff	NonET	ET	ET	ET
4	ET	NonET	NonET	ET	ET	No Diff	ET
5	ET	NonET	NonET	NonET	ET	No Diff	ET
6	ET	ET	ET	ET	No Diff	No Diff	ET
7	ET	ET	ET	ET	ET	No Diff	ET
8	ET	ET	NonET	ET	ET	NonET	ET
9	ET	No Diff	ET	ET	No Diff	No Diff	ET
10	NonET	NonET	NonET	No Diff	NonET	NonET	ET

Fig. 7. Comparison of the AOI metrics of performance for finding the correct areas.

User experience (UX) is highly dependent on the user's internal state of mind and context of use [30]. Additionally, UX is flexible and can change within a day even for the same user and the same product [22]. This may mean that the findings are valid only at a particular time and for the specific context. One participant said that he had forgotten what he was looking for, asking for the question to be repeated, and hence he took a long time to answer the question. Intelligence or the ability to focus may impact how effectively a person searches for information. A person's emotional state (of nervousness or uncertainty) may also impact how they search for information on the screen. Thus, it is essential to recognize that differences may have existed not only in the degree of familiarity with the system and the content, but from other characteristics of the participants too.

Another potential source for the differences may come from the fact that the students from the eye-tracking course were previously engaged in the creation of experiments, which utilized the eye-tracking equipment. The overall experience of being surveyed with the eye-tracking equipment may have added additional pressure – emotionally and cognitively – which may have been novel and stressful to the NonET group. One of the participants mentioned that it was unclear for him what was needed, and that adding simpler tasks at the beginning of the experiment could have facilitated his performance. The ET group might have been more experienced in terms of being surveyed by the eye-tracking technology and thus more confident, which may have affected their user efficiency performance positively during the experiment. Furthermore, as [14] mentions, eye-tracking technology by itself is only a measure of the user's interest, although it could not be used to identify whether the object of interest is liked or disliked. Hence, the results of this research are ideally viewed as complementary to other methods of user surveying.

VI. Conclusion

A. *Concluding Remarks and Future Work*

Eye-tracking methodology was shown to be an appropriate approach to gain important insights into the usability and UX of the LMS utilized in this study. It was found that there were some areas which users referred to more frequently than others when answering particular questions. This may be because, in the IS interface, there are certain areas ("practical area" and "course content area") that are considered to have different purposes by users, and users refer to these areas for different purposes, as measured by the task question. There were also some elements of the design that could be considered "visible" or "non-visible" (based on how easy it was to find them). Further research into validating those concepts is needed.

It is also possible to indicate that there were differences in how users who had used the content over some time displayed a better performance compared to those users who were not exposed to the content previously. The differences could be seen in the eye-movement patterns, user efficiency, effectiveness of completing the tasks and AOI metrics. As a result, the data indicated that the usability and UX of the course content as part of LMS were affected by the familiarity with the course content. A better methodology could be employed in the future to validate the potential differences in the effect of familiarity on the usability and UX of an LMS.

As mentioned earlier, few studies present a comparison of the different techniques in measuring the usability and UX of LMSs. This makes it challenging to define the most effective technique for the e-learning context [15]. This research contributes to the literature by addressing the research gap by employing several techniques and by comparing the results in a summarized form. It was found that eye-movement differences were correlated with the differences in user effectiveness, user efficiency and AOI metrics, although not always. In general, it was found that the shorter the scan path and fixations, the better the user efficiency. Further research may focus specifically on analyzing what are the elements in the eye-movement data that tend to correspond to a greater user effectiveness and efficiency of an LMS.

B. *Limitations*

The research has several limitations, including the method which was used to analyze eye-tracking data and the self-reported answers given by the participants. Although the researchers did their best to collect, document and analyze the data as accurately as possible, the findings of this research must be assessed carefully. Furthermore, the research has the typical limitations related to qualitative research [31]. Convenience sampling is a method used to choose participants who are available and easy to find [32]. There may exist a bias towards results, which does not allow extrapolating the findings reliably to a greater population. It is important to note that the two survey groups were at least partially experienced with the use of Moodle (4 months) in addition to being experienced using an LMS in general (up to 5 years previous use experience). The small sample size and the fact the data were collected in a single university may not allow extrapolating to the greater population of LMS users.

Users were asked to perform tasks with the screenshots, but not with the website itself, and as such, the interactions with the website were a simulation of the real use of the LMS. Participants were also asked to review the course content of only one course hosted on the Moodle LMS. Course content may differ in other courses and other LMSs. Hence, the findings might not be applicable in other contexts. During the experiment, the participants interacted with the researcher by asking questions as well as by giving answers. As noted by [33], it is well-established in the literature that the mere presence of the researcher could contribute to bias of the participants and them behaving in a certain way, referred to as the "researcher bias". Additionally, a potential lag (about 2–3 seconds) could exist between the participant's answer and the researcher's agreement with the response as correct.

One participant reported that her English proficiency level was 6 out of 7; however, in the comments, she wrote the sentence, "used other system than Moodle before," which uses the preposition "other than" incorrectly. Thus, self-evaluation of the English proficiency, and even other themes, may be biased by the participants to be higher or lower. The order of the tasks may also impact the survey results, as commented by the P6, who stated that if he were to look for the visible elements, in the beginning, it would have been more natural for him to understand how to go through the eye-tracking experiment. Gender difference has no significant impact on the typical UX factors of different website designs [34]. However, [35] claims that in e-learning, there are differences in the interaction with the IS between females and males. Besides, another research stated that males could better interpret the technical ingenuity of a web banner, such as evaluating the present visual and audio features. As a result, [36] states that gender should be included as a factor when evaluating the UX of web design. Finally, [37] concludes that the perception and satisfaction of a website differs within cultural clusters and gender groups. Hence, gender and cultural differences are factors that potentially could have affected the study results.

REFERENCES

[1] Brusilovsky, P: A Distributed Architecture for Adaptive and Intelligent L.M.S.; AIED 2003.

[2] Dahlstrom, E., Brooks, D.C. and Bichsel, J., 2014. The current ecosystem of learning management systems in higher education: Student, faculty, and IT perspectives.

[3] Ramakrisnan, P., Jaafar, A., Razak, F.H.A. and Ramba, D.A., 2012. Evaluation of User Interface Design for Leaning Management System (LMS): Investigating student's eye tracking pattern and experiences. *Procedia-Social and Behavioral Sciences*, *67*, pp.527-537.

[4] Ayub, A.F.M., Tarmizi, R.A., Jaafar, W.M.W., Ali, W.Z.W. and Luan, W.S., 2010. Factors influencing students' use a learning management system portal: Perspective from higher education students. *International Journal of Education and Information Technologies*, *4*(2), pp.100-108.

[5] Marks, L.J. and Olson, J.C., 1981. Toward a cognitive structure conceptualization of product familiarity. *ACR North American Advances*.

[6] Chakravarti, A., Place, D., George, E.M. and Vandervort, J.L., 2018. EduLink: Connecting Educators across Namibia through a Learning Management System.

[7] Ruiz-Molina, M.E., Marín-García, A. and Llopis-Amorós, M.P., 2018. Moodle: the More you Use it, the More you Love it? Evidence about Perceived Usefulness of Moodle from International Business Students. In *Conference Proceedings. The Future of Education* (Vol. 18, No. 9, p. 99). libreriauniversitaria. it Edizioni.

[8] Green, R.A. and Hughes, D.L., 2013. Student outcomes associated with use of asynchronous online discussion forums in gross anatomy teaching. *Anatomical sciences education*, *6*(2), pp.101-106.

[9] Sayfouri, N., 2016. Evaluation of the learning management system using students' perceptions. *Medical journal of the Islamic Republic of Iran*, *30*, p.460.

[10] Norman, D.A., 2009 Memory is More Important than Actuality. Interactions, March + April, pp. 24–26.

[11] Hsee, C.K. and Hastie, R., 2006. Decision and experience: why don't we choose what makes us happy?. Trends in cognitive sciences, 10(1), pp.31-37.

[12] Davenport, T.H. and Beck, J.C., 2001. *The attention economy: Understanding the new currency of business*. Harvard Business Press.

[13] Schifferstein, H.N. and Desmet, P.M., 2007. The effects of sensory impairments on product experience and personal well-being. *Ergonomics*, *50*(12), pp.2026-2048.

[14] Velásquez, J.D., 2013. Combining eye-tracking technologies with web usage mining for identifying Website Keyobjects. Engineering Applications of Artificial Intelligence, 26(5-6), pp.1469-1478.

[15] Nakamura, W.T., de Oliveira, E.H.T. and Conte, T., 2017. Usability and User Experience Evaluation of Learning Management Systems. In *Proc. of the 19th International Conference on Enterprise Information Systems* (Vol. 3, pp. 97-108).

[16] Isakowitz, T., Bieber, M., & Vitali, F. (1998). Web information systems. Communications of the ACM, 41(7), 78-80.

[17] Dalsgaard, C. (2006). Social software: E-learning beyond learning management systems. European Journal of Open, Distance and e-learning, 9(2).

[18] Machado, M. and Tao, E., 2007, October. Blackboard vs. Moodle: Comparing user experience of learning management systems. In *2007 37th annual frontiers in education conference-global engineering: Knowledge without borders, opportunities without passports* (pp. S4J-7). IEEE.

[19] Norman, D. (1999). Invisible Computer: Why Good Products Can Fail, the Personal Computer Is So Complex and Information Appliances Are the Solution. MIT Press. 1999, ISBN 978-0262640411

[20] Pallot, M., 2012. A holistic model of user experience. Webergence Blog Retrieved May.

[21] Fenko, A., Schifferstein, H.N. and Hekkert, P., 2010. Shifts in sensory dominance between various stages of user–product interactions. Applied ergonomics, 41(1), pp.34-40.

[22] Karapanos, E., Zimmerman, J., Forlizzi, J. and Martens, J.B., 2009, April. User experience over time: an initial framework. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 729-738). ACM.

[23] Nakamichi, N., Shima, K., Sakai, M. and Matsumoto, K.I., 2006, May. Detecting low usability web pages using quantitative data of users' behavior. In *Proceedings of the 28th international conference on Software engineering* (pp. 569-576). ACM.

[24] Razeghi, R., 2010. Usability of Eye Tracking as a User Research Technique in Geo-information Processing and Dissemination. University of Twente Faculty of Geo-Information and Earth Observation (ITC).

[25] Behe, B.K., Fernandez, R.T., Huddleston, P.T., Minahan, S., Getter, K.L., Sage, L. and Jones, A.M., 2013. Practical field use of eye-tracking devices for consumer research in the retail environment. *HortTechnology*, *23*(4), pp.517-524.

[26] Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H. and Van de Weijer, J., 2011. Eye tracking: A comprehensive guide to methods and measures. OUP Oxford.

[27] Bojko, A., 2005. Eye tracking in user experience testing: How to make the most of it. In Proceedings of the UPA 2005 Conference.

[28] Bojko, A., 2006. Using Eye Tracking to Compare Web Page Designs: A Case Study.

[29] Holzinger, A., Stickel, C., Fassold, M. and Ebner, M., 2009, November. Seeing the system through the end users' eyes: shadow expert technique for evaluating the consistency of a learning management system. In Symposium of the Austrian HCI and Usability Engineering Group (pp. 178-192). Springer, Berlin, Heidelberg.

[30] Hassenzahl, M., Tractinsky, N., 2006. User experience – a research agenda. Behaviour & Information Technology 25 (2), 91–97

[31] Yin, R. (2003). Qualitative Research from Start to End, New York, NY; The Guilford Press.

[32] Saunders, M., Lewis, P., & Thornhill, A. 2009. Research Methods for Business Students. 5th edition, Pearson Education Limited

[33] Miyazaki, A.D. and Taylor, K.A., 2008. Researcher interaction biases and business ethics research: Respondent reactions to researcher characteristics. *Journal of Business Ethics*, *81*(4), pp.779-795.

[34] Aufderhaar, K., Schrepp, M. and Thomaschewski, J., 2019. Do Women and Men Perceive User Experience Differently? IJIMAI, 5(6), pp.63-67.

[35] Ong, C.S. and Lai, J.Y., 2006. Gender differences in perceptions and relationships among dominants of e-learning acceptance. Computers in human behavior, 22(5), pp.816-829.

[36] Alkhaldi, A.N. and Al-Sa'di, A., 2018. Gender Differences in User Satisfaction of Mobile Touch Screen Interfaces: University Students' Service Sites. International Journal of Innovation and Technology Management, 15(06), p.1950003.

[37] Simon, S.J., 2000. The impact of culture and gender on web sites: an empirical study. ACM SIGMIS Database: the DATABASE for Advances in Information Systems, 32(1), pp.18-37.