

Efficiency and effectiveness of the old and new versions of the bank's website by investigating users' behavior with the eye tracker technique

Abstract

The present study aimed to examine the efficiency and effectiveness of the old versus new bank website versions by investigating the users' behavior with the eye tracker technique. To identify these effective factors, usability evaluation methods and user experience are key elements that must be considered. This research was conducted in the A / B test phase and the data collection tools were a questionnaire and an eye tracker. A combination of quantitative and qualitative approaches was used to analyze the data. This study used inquiry techniques and user testing methods to evaluate the usability of Internet banking systems. The results were analyzed and the iteration method was employed in the third study to redesign the initial sample in one of the banks that had the lowest usability score. The two versions were compared and the results showed that a better user experience was obtained in the modified version. The results showed that there was a significant difference between the old and new websites in terms of satisfaction, efficiency, effectiveness, learning, and security in performing the activities. The results showed a significant difference between the old and new versions of Bank B throughout the process in terms of the number of fixations. There was also a significant difference between the new and old versions of Bank B throughout the process in terms of duration of fixation. Also, there was a significant difference between the new and old versions throughout the process in terms of the total duration of all fixations.

Keywords: Internet Banking, Usability, Eye Tracking, Heuristic Method, A / B test

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Introduction

The demand for high-quality software systems, which provide adequate efficiency, performance, and satisfaction to end users is growing rapidly (Madan & Dubey, 2012). This issue can be seen among various organizations in the private sector (Bias and Mayhew, 2005) and the public sector (Buie and Murray, 2012). Accordingly, the focus on the usability of these system types has increased and received significant popularity (Bygstad, Ghinea, and Brevik, 2008, Stary and Eberle, 2008). Internet banking can be considered from two points of view, customers and banks. From the customers' point of view, we can refer to the benefits of cost savings, time-saving, and ease of access for banking operations, whereas from the banks' point of view, we can refer to features such as creating and increasing the bank's reputation in providing innovation, customer retention despite spatial changes of banks, creating opportunities to seek new customers in target markets, expanding the geographical scope of activities and reducing costs (Rostami, Khani, Soltani, 2016). The simplest form of Internet banking to display information about the bank, products, and services is through the World Wide Web. These pages enable the interaction between customers and the banks providing an exchange of information. It is also used as a mechanism for customers to submit their complaints and suggestions while developing interactions, sales systems, new services such as e-mail, and to transfer money and information.

Website designers give a high level of freedom of action for innovation and creativity when designing a website, but some guidelines and frameworks need to be considered for greater success. Designing a site whose appearance is interesting but understanding the content is difficult will cause the whole project to be unusable for the user. The most important principle of a successful design is to create a proportional balance between performance and structure (Rostami, Khani, Soltani, 2016). The first law of e-business states: If users cannot find the product, they cannot buy it! Thus, improving usability is a great way to encourage users to visit your website instead of other websites that belong to your competitors. The usability encourages customers to use the site. In fact, high-quality websites that are easy to use bring customers and make the website an arena to compete with competitors. One of the most important aspects of creating a website is its usability. Usability shows how easy and convenient it is to use a product (website) and its benefits to the user (Andreasen et al., 2007). Usability assessment aims to achieve the degree to which the system is effective (how well the system performs the tasks for which it is designed) and efficient (how much resources such as time and effort are required to use the system to perform the tasks for which it is designed) and creates favorable attitudes and reactions in users. The importance of web-based and mobile products in the banking industry, which is a prominent competitive feature, doubles the need to address the concept of

usability. The usability of websites in software science has been examined in various ways, but what makes this research special is the use of website usability with a new marketing tool, the eye tracker. The reason for it is changes at the level of hundredth of a second that cannot be transmitted by clicking through search engines (Nielsen, 2006). Hence, the present study aimed to investigate the efficiency and effectiveness of the old and new versions of the bank's website by examining users' behavior with the eye tracker technique.

Theoretical foundations of research

Usability

Usability is defined as "quality in use" (Arban, 2003; ISO 14598, 1999). One of the good definitions is the International Organization for Standardization (ISO) (Arban et al., 2010), which presents three basic dimensions of usability. These three dimensions are effectiveness, efficiency, satisfaction, and defining usability in this standard as "the level of product use by specific users to achieve specific goals with efficiency, effectiveness, and satisfaction in a specific area of using that product" (Arban et al., 2003; Stone et al., 2005). Defining usability requirements is considered the most difficult task for systems development and modernization (redesign) that is related to the processing of three activities: analysis of the area of use, the definition of work scenarios to be tested, and determining the requirements for effectiveness, efficiency, and satisfaction for each scenario. Usability requirements are divided into four groups. Since the importance of usability has been widely introduced as having a multidimensional aspect, several studies have offered different perspectives on several key usability features, including effectiveness, efficiency, learning (easy learning), tolerance of error, and satisfaction) (Nielsen; Dix et al, 1993; ISO 9241-11, 1998; Shneiderman, 1998; Quesenbery, 2004; Holzinger). Arban et al. (2003) claimed that determining the features and dimensions of usability has been challenged by the nature of these features and would depend on the framework in which the system was used. The five most used features by researchers are ease of learning, efficiency, effectiveness, satisfaction, and security.

To evaluate the effectiveness feature, for most tasks, we can use a pass/failure criterion: whether the user was able to perform the task successfully. Accordingly, the percentage of users who can successfully perform the task (one dimension of system usability) is measured (Fidgeon, 2011). Quesenbery's research in 2004 described efficiency as the speed with which users do tasks accurately. Another explanation is that when these users learn how to use the system, how quickly they can get the tasks done and the ability to achieve a high level of productivity (Holzinger, 2005). An appropriate way to measure this feature is to calculate the time taken by users to perform the tasks (Fidgeon, 2011). The error feature is how the system prevents user errors or how correctable if an error

occurs, which allows users to make fewer errors when working with the system. A learning feature that we can call easy of learning indicates how easily users complete a particular task the first time they interact with the system. This means that they can start working with the system quickly. Also, it should be noted that a system may be used at different times. Also, the system itself may help users in a task and these people themselves can be experts or novices (Holzinger, 2005).

Eye-tracking

Eye-tracking is one of the most advanced tools to examine, record, and measure physiological changes and eye movement of individuals (Lohmeyer, 2014). Using the Radiation patterns, optical sensors, and tracking corneal reflection, it provides information about the position, direction of look, and eye movements with very high accuracy. It is also widely used as a technical and cognitive tool to analyze the perceptions, unconsciousness, and realizing audience (Zurawicki & Leon, 2010).

Methods

To test the research hypotheses, experimental research methods (laboratory type) were used. In terms of aim and description in terms of the data collection method, this study can be considered applied research. Since this study investigates user behavior, before starting the study, the ethics form (observing the confidentiality and user consent) was collected from the participants. To achieve the first aim, the experiment-based usability test method was used to measure ISO 9241-11 criteria, which are effectiveness, efficiency, and satisfaction (Civinji and Abdullah, Daw and Ahmad, 2015). Before starting the real study of the individuals, a pilot test was performed to ensure the readiness of the test environment and the accuracy and settings of the device.

Table 1: List of usability test tasks

Tasks	Explanations
Task 1	Please deposit money into an account. When done, press the 1 key.
Task 2	Please charge a cell phone. Press the 2 keys when done.
Task 3	Please get a facility account. Press the 3 key when done.
Task 4	Please pay the bill. Press the 4 key when done.

Since the presence of subjects at the experiment site of the University of Tehran was obligatory, the statistical population in the experimental section of the study was students. A convenience random sampling method was used. For this purpose, 200 students from the North Tehran branch and 100 students from the University of Tehran, who announced their consent to participate in this experiment, were randomly

selected and their names were selected if they announced their readiness again on that date, they were selected.

The eye tracker used in this research was SME, RED 250. It includes a 17-inch monitor with a resolution of 900 x 1600 to provide a stimulus. It is an infrared device for recording eye movements at a sampling speed of 250 Hz per second with Tubi Studio software. It calculates and reports the values of measurement error of the eyes fixation site and accordingly experimental attempts with high errors can be detected and excluded from the analysis. The stimuli provided by this device include the image, video, text, web pages, and so on. This device has the capability of defining the simultaneous and diverse EOI and gives various outputs, including numerical data that can be analyzed in SPSS and a variety of contents and graphical analyses. Before starting the experiment, the eye tracker should be calibrated for each subject.

To measure the level of visual attention of subjects by this device, the stimulus is presented first on the monitor screen and the infrared receiver records the eye movements, dynamic movements of the pupil, and visual stimulator content when observing the screen at the sampling speed of 250 seconds per Hertz and automatically analyzes the areas selected by the user in the subject's scope of vision. The questionnaire was used as a tool to collect the data in this study. For this purpose, it was tried to obtain the maximum validity of this tool. Matching experiment environmental conditions: room size, the time interval of experimenting (from 9 am to 12 am every day, environmental sound (acoustic room), keeping the variables of social status, age, and culture of subjects fixed, so that subjects were living in Tehran (cultural similarity) and were at the age range of 20 to 30 years. Finally, homogenous groups were formed and no distinctive characteristic that affects the dependent variable was found in any groups.

To prevent historical bias, necessary explanations were provided on adequate rest a day before the participation in the experiment for the participants so that their eyes movement experiment not be affected by insomnia and fatigue. Also, subjects with visual impairments were excluded from the list of participants. During the experiment, all participants continued cooperating and all of them were active from beginning to the end of the experiment and no dropout was observed. It should be noted that 3 subjects who did not complete the calibration stage were not tested. A single questionnaire and eye tracker were used in all experiments and before any experiment; the calibration of the eye tracker was controlled. Also, the human force was not involved in the measurements and the research was free of tool bias.

Participating in the research is a new and often exciting experiment for many people. In this new situation, people may show behavior different from usual environments and the real world. For this purpose, the laboratory official and the

researcher had almost 5 to 6 minutes of friendly dialogue with each subject at the laboratory site before the experiment. Then, they explained the research objective but not in a way that affects the results. After completing the primary characteristics of the questionnaire the subjects, the experiment started under normal conditions. Since subjects had three tests for 10 minutes with a 30-minute rest between each test, the research is free of test effects bias (effects of exercise, fatigue, and transfer) or the regression order effects towards maturity mean. During the experiments, no potential clue of the research objective or hypotheses that affect the participants' behavior to confirm or reject the hypotheses in specific ways was found. Also, a good and bad subject error was not found in the research. The researcher preceded the experiment stages based on the executive guidelines and showed standard and similar behavior with subjects to prevent the tester bias. It was also tried that the study not be affected by the intentional unethical behavior and indirect notification of the expectations and personal beliefs of the researcher. To prevent treatment transmission error, to analyze and conclude correctly, the subjects were reminded that they should not give any explanation about the experiment to their friends who would attend the laboratory in the coming days.

Also, due to the limitation on the presence of different people in the laboratory in the experiment time interval, necessary coordination was made with them on the hours of their attendance, and the times were set with a 30-minute time interval so that after completing the experiment, the next person attended the site and accordingly the overcrowding at the laboratory site was prevented. For the participation in the inter-subject plan, the same compensatory behavior was applied to the participants and there was no inequality or specific competition among the participants.

Research objectives in Phase 3

1- Investigating the differences between the old and new versions of Bank B in terms of satisfaction in performing the activities

2- Investigating the differences between the old and new versions of Bank B in terms of efficiency in performing the activities

3- Investigating the differences between the old and new versions of Bank B in terms of effectiveness in performing the activities.

4- Investigating the differences between the old and new versions of Bank B in terms of learning in performing the activities

5- Investigating the differences between the old and new versions of Bank B in terms of security in performing the activities

Also, the following objectives were investigated in this phase using eye-tracking.

- 1- Comparison of old and new versions of Bank B on the login page in terms of differences in the number of fixations
- 2- Comparison of old and new versions of Bank B on the tasks page in terms of significant differences in the number of fixations
- 3- Comparison of old and new versions of Bank B in all pages seen in terms of significant difference in the number of fixations
- 4- Comparison of old and new versions of Bank B in terms of the duration of a fixation on the login page
- 5- Comparison of old and new versions of Bank B in terms of the duration of a fixation on the test page
- 6- Comparison of the old and new versions of Bank B in terms of the duration of fixation seen on all pages
- 7- Comparison of old and new versions of Bank B in terms of the total duration of all fixations on the login page
- 8- Comparison of old and new versions of Bank B in terms of the total duration of all fixations on the task page
- 9- Comparison of old and new versions of Bank B in terms of the total duration of all fixations

Based on the experiment objective, the visual attention of the audience to the website, the eye fixation duration of the audience, and the number that has a significant relationship with effectiveness, efficiency, satisfaction, and learning will be measured. The measures in the questionnaire would be effectiveness, efficiency, security, and satisfaction. The information on eye movements related to the website page in the form of fixation duration and its number will be extracted using Tubi Studio Software.

Results

A / B test was performed to analyze the collected data. A questionnaire and an eye tracker were used to collect the data. Since the data obtained from the eye tracking device is abnormal, non-parametric tests (Friedman test) were used for further analysis of them and testing of the hypotheses. In the old website group, 23.5% of the participants of the study are under 20 years old, 4.2% are in the age group of 20-25 years, 17.6% are in the age group of 25-30 years and 17.6% are in the age group of 30 years and above. In the new website group, 29.4% of the participants are under 20 years old, 17.6% are in the age group of 20-25 years, 29.4% are in the age group of 25-30 years and 23.5% are in the age group of 30 years and above. In the old website group, 47.1% of the participants are female and 52.9% are male. In the new website group, 64.7% of the participants are female and 35.3% are male. In the old website group, 17.6% of the research participants have a diploma and under diploma education, 5.9% have an associate, 35.3% have a bachelor and 4.2% have a master's level of education. In the new website group, 17.6% of the research participants have a diploma and under diploma, 41.2% have an associate's, 7.6% have a bachelor and 23.5% have a master's level of education.

On the old website, the mean of satisfaction in performing activities was 0.76, the mean of efficiency in performing activities was 0.88, the mean of effectiveness in performing activities was 0.82, the mean of learning in performing activities was 1.12, and the mean of security in performing activities is 1.2. On the new website, the mean of satisfaction in performing activities was 2.27, the mean of efficiency in performing activities was 2.33, the mean effectiveness in performing activities was 2.37, the mean of learning in performing activities was 2.4, and the mean of security in performing activities was 2.72.

Table 2: Kolmogorov-Smirnov test to check the normal distribution of research data

Variable	statistic K.S	sig	Normal distribution
Satisfaction in performing the activities	1.085	0.189	yes
Efficiency in performing the activities	0.91	0.379	yes
Effectiveness in performing the activities	0.714	0.687	yes
Learning how to perform the activities	0.76	0.61	yes
Security while performing the activities	1.046	0.224	yes

As the results of Table 2 show, the value of the significance level of the research variables is more than 0.05, so the null hypothesis is confirmed with 95% confidence and it can be stated that the distribution of data in the research variables follows the normal distribution.

1- A comparison between old and new websites

Hypothesis 1: There is a significant difference between the old and new websites in terms of satisfaction in performing activities.

Table 3: Mean satisfaction in performing activities

Satisfaction in performing activities	Mean	SD
Old website	0.764	0.752
New website	2.27	0.519

Based on the results of Table 3, the mean satisfaction in performing the activities is 0.764 for the old website and 2.27 for the new website.

Table 4: Independent t-test for satisfaction variable in performing the activities separately based on website

Levene's test		Independent t-test				
statistic F	sig	statistic t	df	sig	95% confidential interval	
					Lower bound	Upper bound
4.464	0.0430	-6.791	28	0.000	-1.95	-1.05

Table 4 examines the test of mean satisfaction in performing the activities separately based on the website. First, the assumption of the equality of variance between the two groups is examined. Since the significance level of Levene's test (0.043) is less than 0.05, the assumption of the equality of variances is rejected. In the independent t-test, the test statistics and the degree of freedom are -6.791 and 28.424, respectively. The significance level of the test is 0.000. Since the significance level is less than 0.05, it can be said that there is a significant difference between the old and new websites in terms of satisfaction with performing the activities. Therefore, the above hypothesis is confirmed.

Hypothesis 2: There is a significant difference between the old and new websites in terms of efficiency in performing the activities.

Table 5: Mean efficiency in performing the activities

efficiency in performing the activities	mean	SD
old websites	882.0	58.0

Table 7: Mean effectiveness in performing the activities

effectiveness in performing the activities	mean	SD
old websites	823.0	607.0
new websites	37.2	478.0

Based on the results of Table 7, the mean effectiveness in performing the activities is 0.823 for the old website and 2.37 for the new website.

Table 8: Independent t-test for effectiveness variable in performing the activities separately based on website

Levene's test	Independent t-test
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new websites	2.338	0.423
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According to the results obtained from Table (5), the mean efficiency in performing the activities is 0.882 for the old website and 2.338 for the new website.

Table 6: Independent t-test for the efficiency variable in activities separately based on the website

Levene's test		Independent t-test				
statistic F	sig	statistic t	df	sig	95% confidential interval	
					Lower bound	Lower bound
2.062	0.161	-8.356	32	0.000	-1.81	-1.1

Table 6 examines the mean efficiency test in performing the activities separately based on the website. First, the assumption of the equality of variance between the two groups is examined. Since the significance level of Levene's test (0.161) is more than 0.05, the assumption of the equality of variances is accepted. The significance level of the test is 0.000. In the independent t-test, the test statistics and the degree of freedom are -8.356 and 32, respectively. The significance level of the test is 0.000. Since the significance level is less than 0.05, it can be said that there is a significant difference between the old and the new websites in terms of efficiency in performing the activities. Therefore, the above hypothesis is confirmed.

Hypothesis 3: There is a significant difference between the old and new websites in terms of effectiveness in performing the activities.

statistic F	sig	statistic t	df	sig	95% confidential interval	
					Lower bound	Lower bound
824.0	371.0	274.-8	32	000.0	93.-1	17.-1

Table 8 examines the mean effectiveness test in performing the activities separately based on the website. Since the significance level of Levene's test (0.371) is more than 0.05, the assumption of the equality of variances is not rejected. In the independent t-test, the test statistics and the degree of freedom are -8.274 and 32, respectively. The significance level of the test is 0.000. Since the significance level is less than

Table 9: Mean learning in performing the activities

learning in performing the activities	mean	SD
old websites	1.12	0.681
new websites	2.4	0.533

Based on the results of Table 9, the mean learning in performing the activities is 1.12 for the old website and 2.4 for the new website.

Table 10: Independent t-test for the variable of learning in performing the activities separately based on website

Levene's test		Independent t-test				
statistic F	sig	statistic t	df	sig	95% confidential interval	
					Lower bound	Lower bound
2.735	0.108	-6.05	32	0.000	-1.69	0.842

Table 10 examines the mean learning test in performing the activities separately based on the website. Since the significance level of Levene's test (0.108) is more than 0.05, the assumption of the equality of variances is not rejected. In the independent t-test, the test statistics and the degree of freedom are -6.05 and 32, respectively. The significance level of the test is 0.000. Since the significance level is less than 0.05, it can be said that there is a significant difference between the old and the new websites in terms of learning in performing the activities. Therefore, the above hypothesis is confirmed.

Hypothesis 5: There is a significant difference between the old and new websites in terms of security in performing the activities.

Table 11: Mean security in performing the activities

security in performing the activities	mean	SD
old websites	1.2	0.447
new websites	2.72	0.338

0.05, it can be said that there is a significant difference between the old and the new websites in terms of effectiveness in performing the activities. Therefore, the above hypothesis is confirmed.

Hypothesis 4: There is a significant difference between the old and new websites in terms of learning in performing the activities.

Based on the results of Table 11, the security in performing the activities is 1.2 for the old website and 2.72 for the new website.

Table 12: Independent t-test for the variable of security in performing the activities separately based on website

Levene's test		Independent t-test				
statistic F	sig	statistic t	df	sig	95% confidential interval	
					Lower bound	Lower bound
2.416	13.0	-11.241	32	0.000	-1.81	-1.25

Table 12 examines the mean security test in performing the activities separately based on the website. Since the significance level of Levene's test (0.13) is more than 0.05, the assumption of the equality of variances is not rejected. In the independent t-test, the test statistics and the degree of freedom are -11.241 and 32, respectively. The significance level of the test is 0.000. Since the significance level is less than 0.05, it can be said that there is a significant difference between the old and the new websites in terms of security in performing the activities. Therefore, the above hypothesis is confirmed.

Analysis of eye tracker data in phase 3

Hypothesis 1: There is a significant difference between the old and new versions of Bank B in terms of the number of fixations throughout the process.

Table 13-Rank

variable	Mean rank
Old B	2.53
New B	1.64

According to the table, the mean rank is 2.53 for the old Bank B and 1.64 for the new Bank B.

Table 14: Friedman test

N	Chi-square test	df	sig
17	11.273	1	0.000

According to the table, the value of test statistics is 11.273 and the significance level of the test is 0.000. Since the significance level of the test is less than 0.05 (sig <0.05), the null hypothesis is rejected and it can be said that there is a significant difference between the old and new versions of Bank B in terms of the number of fixations throughout the process with 95% confidence.

Hypothesis 2: There is a significant difference between the old and new versions of Bank B in terms of fixation duration throughout the process.

Table 15: Rank

Variable	Mean rank
Old B	2.35
New B	1.69

According to the table, the mean rank is 2.35 for old Bank B and 1.69 for new Bank B.

Table 16: Friedman test

N	Chi-square test	df	sig
17	5.766	1	0.029

According to the table, the value of test statistics is 5.766 and the significance level of the test is 0.029. Since the significance level of the test is less than 0.05 (sig <0.05), the null hypothesis is rejected and it can be said that there is a significant difference between the new and old versions of Bank B in terms of fixation period throughout the process with 95% confidence.

Hypothesis 3: There is a significant difference between the new and old versions of Bank B in terms of the total duration of all fixations throughout the process.

Table 17: Rank

Variable	Mean rank
Old B	2.35
New B	1.44

According to the table, the mean rank is 2.35 for old Bank B and 1.44 for new Bank B.

Table 18: Friedman test

N	Chi-square test	df	sig
17	10.008	1	0.000

17	10.008	1	0.000
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According to the table, the value of test statistics is 10.008 and the significance level of the test is 0.000. Since the significance level of the test is less than 0.05 (sig <0.05), the null hypothesis is rejected and it can be said that there is a significant difference between the new and old versions of Bank B in terms of the total duration of fixation throughout the process with 95% confidence.

Conclusion

The study aimed to compare the efficiency and effectiveness of the old and new versions of the bank website by examining the behavior of users with the eye tracker technique. The results showed that the biggest usability problem was in Bank B and it was the distances between the execution keys and the selected item. This issue had a strong effect on the usability of the site, so the execution keys were changed and re-examined in the A / B test to make sure that changing them made a significant difference in the sites. Based on the results, it is recommended that the design priority should be on the right side. The login page on the left has information that is not read at all. The most important form of design in eye-tracking maps is the reverse F, meaning that the design on the right should have the most important information, while the left side is considered less important.

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Conflict of interest

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Ethics statement

None

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