The Usability Heuristic factors for Sensors monitoring system A case study of laboratory Animal Research Center

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ABSTRACT

Nowadays, information technology solutions are significant methodology to support and improve in many organizations such as governments, business companies, education and developing countries. In addition, there are several platform of technology is able to connect to people. Presence, Internet of Things (IoT) platform has an advantages value in terms of three majority points of view. Fast response, Support Human errors and Powerful Collector tool. According to a newer platform, there are some significant point to research about user experience (UX) and user interface (UI). This research focuses on user's interaction and their responses while they were using sensors monitoring system to find an important factor of usability heuristics (USH) Jakob Nielsen's 10 general principle for interaction design with two different software version within this research area. The first version (V1) has been used about a year after that researchers' team collect a weak point factor to develop into the second version (V2). V1 and V2 are used to ensure that these factors can be significant factors as a part of IoT platform development by using Chi Square statistical. Moreover, this result from Chi Square statistic method is a valuable key to implement a beneficial human interaction of IoT system. Lastly, the case study has been used the real world software which is being use at laboratory animal research center (LARC), University of Phayao

Keywords: Usability Heuristics (USH), Internet of things (IoT), User experience (UX), User interface (UI), Chi Square

INTRODUCTION

At presence, technology have become an important part of people such as growing business, support manufacturing, education, government and developing countries. This research focused on IoT platform which is used in Animal laboratory research center, University of Phayao. There are three main keys to stand by IoT platform within this research area.

IoT platform is productive system including tracking and monitoring control. LARC using animal for scientific research, gas sensor and temperature keep monitoring and report to researcher every time when the value jump over red line. According to a report from the monitoring system, it can be applied a collection of

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numerous dataset as an input in Machine learning to predict and analyze. Furthermore, technology of artificial intelligence can reduce human failure from repetitive research tasks.

At the beginning of a research, there was the first version (V1) of IoT system. V1 is used without usability testing of USH. At initial phase, this research aims to find a weak point usability of an origin version by collecting data from respondents at LARC with survey questionnaire method based on 10 usability heuristics principle. These minorities result will be continued to improve into the new version (V2).

In the next step, the V2 will be tested by survey questionnaire method once again to ensure that there is less score of the same weakest result than V1. In addition, the second survey questionnaire will be collected with the same respondents in different features. Nearly the end phase, the Chi-Square test has been chosen as a statistic method in this research. The Chi-Square test can be used for testing relationships between V1 and V2 to improve better human interaction for IoT System. From an overall mentioned above, the aims of this research is to recommend a principle standard of interaction design for a particular system, IoT. In the opposite point of view, this research can be shown a poor example of bad design interaction as well.

Furthermore, this research is a future study for other related research fields of designing principles to improve a quality of user interface and user experience for interaction software by using case study of an IoT platform.

RELATED WORK

In this part are shown other correlation from previous research studies. There are two outstanding resources which is related to the objective of this research about usability testing for Technology Platform and IoT Interaction Design.

I. Usability Testing Parameter for Technology Platform

Recently, usability engineering is becoming importance for testing software product and there are many usability testing methods such as survey, observation and heuristics evaluation. This research study challenge with testers to find a great usability assessment parameter by following Jakob Nielsen's 10 usability heuristics (Nielsen, 1994). Moreover, this research aims to find out the best practice factors for usability testing to evaluate the University website. Survey method and heuristic evaluation are chosen in this research to confirm between positive and drawbacks aspect of the university website. Another benefit of this result is to ensure that Neilson’s law 10 Usability heuristics is a significant usability testing method for testers (Lodhi, 2010). According to the research result there are some new usability heuristic factors which is related to an original. Visibility and Clarity of system Elements indicated that the most significant of user interface is clean visible (Paz, 2016). In addition, Alignments to Web Standard design result shown that system supposed to follow the website standard which are come from a conclusion of design convention. From an overall between Affifa and Freddy Paz shown a similar outcome that usability heuristic is an advantage method of usability testing in case of website. They found a clear picture of benefit to use heuristic method provide more opportunity

for tester to notify every position of software product before release to customer. However, there are some drawbacks aspect about 10 Neilson's law when tester choose to evaluate in different technologies platform. In some other information, factors need to be redefined for a particular platform. Next topics below will be mentioned about this research evidences.

II. Heuristics redefined for Internet of things platform

In the technology trend 2020 mentioned that "Growth in Data and Device with more Human Device Interaction" at the end of 2019 there are more than 3.6 billion devices were using the 5G internet. At this reason, the usability testing in an IoT platform is become more necessary. There are several technology platforms can be used with basic principle of Neilson's laws. For example, registration, transaction and others general systems for daily tasks. In 10 usability heuristics noted many majority concepts to be standards of UI design.

However, there are some minority drawbacks about standard principle of Neilson's laws. In a particular process depending on technology platform. There is standard principle of Neilson's laws presented in a different aspect to use in IoT platform. According to usability heuristic reorganized principle for IoT (Manisha, 2016) indicated that the Nielsen's law will be more benefit for IoT platform when they are developing an interface to be useful and useable. In their previous research are focused on how to revisited in term of IoT devices in case study of Mini Drone devices capture aerial view. In addition, there are two standing point out of ten Nielsen's law of redefined IoT based system. At the law of user control freedom, the result shown that freedom control are user-friendly. The device allow users to make their own decision to complete each mission smoothly by providing useful functions and feature such as adjust camera, control speed and direction. Next point in term of System in the real world, there are environment sensor embedded on mini drone to itself for accidental damage. This result represented that the device adjust itself to a real world which is environmental obstacle by using sensors detections (Nielsen, 1994).

In conclusion, Nielsen's law defined the key point for generic principle for interaction design which are providing 10 not specific usability guidelines for developer to apply to their
own tasks.

THEORY AND METHODS

In theories and evaluation methods, there are some benefits aspect to follow Neilson's law which is a standard of User interface and User experience for Interaction software. In this research study discuss on two generation of IoT platform with the similar boundary requirement. The result will be redefined a new principle usability heurist for a particular platform by using Chi Square statistical method to summarize data. From all key point mentioned above will be described below:

A. Lean user experience

In theories of lean UX, there are three majority fundamentals represent as Think (design thinking), Make (development) and Check (usability testing), (Gothelf, 2013). In terms of thinking related to problem solving capability as shown in figure 1. Next, usability is become an important part before deliver to the next progress to developers.

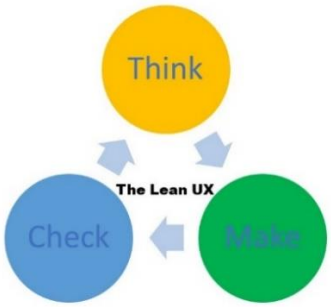

Figure 1 Lean User experience

In figure 2, there are some important view between Lean and Agile UX. Agile UX use an agile process to work with user experience with the main point of collaborative and fast deliver. Lean UX is another subset of agile framework which contain a similar process but it concentrates on getting feedback as fast as possible. In addition, Lean UX also use for measuring and validating for a final design. However, both techniques need to end up at the same position, same result via different path. Agile UX helps designer change to a new way to produce product and Lean UX support their product quality as shown in figure 2.

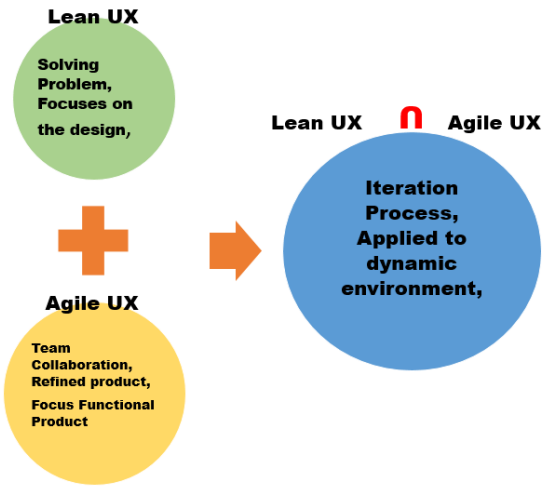

Figure 2 Agile User experience and Lean User experience

B. User Interface

After a clear requirement from customer in above section from User experience, the designer team will be delivered the final task to the developer team which is the user interface (UI) design. UI is represented a clear view from requirement message to productivity (Galitz, 2007). It is also a subset of human-computer interaction (HCI). HCI is another important designer skill to find out satisfactions of users such as expectation, limitation abilities and enjoyable. Furthermore, the designer must aware the limitation of hardware and software system. UI is a representative of window to view all functional inside. Galitz mentioned that well-Design can help company save budget and productivity improved 25 to 40 percent.

Lastly, UX/UI designer can be one or two person which is depending on experiences. UX designers' characteristic is critical thinking in terms of design ideation, research and observation. UI designer specialize is design spec and interface design which is relate to systematic thinking.

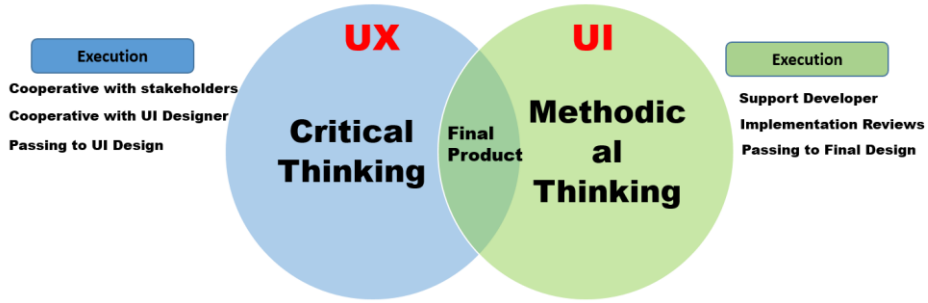

Figure 3 User experience and User interface

C. Neilsen's Law with IoT Platform

There are several usability testing methods to evaluate software quality grow rapidly (Chontisarn, 2016). Neilson's law is one of the most popular standards for frontend developer to use as a method to evaluate software design quality. There are 10 usability heuristics principle as shown in table 1:

Table 1 Neilson's Usability heuristic laws

No.	Concepts
U1	**Visibility of system status:** feedback loop from customer within responsible time
U2	**Match between system and the real world:** the software communicates in human language
U3	**User control and freedom:** provide an optional function for user to find out the exit
U4	**Consistency and standard:** the standard of clear view of text for user such as font size
U5	**Error prevention checklist:** Visible data for every failure cases
U6	**Recognition rather than recall:** Record and playback places where user have been visited

U7	**Flexibility and efficiency of use:** flexibility system can be adapted to several platforms with different culture system.
U8	**Aesthetic and minimalist design:** reduce unnecessary elements or attributes
U9	**Help users recognize:** suggest optional solutions for user
U10	**Help and documentation:** provide a guideline information for users to understand all important features of system.

In addition, there are two significant principles from Neilsen's law can be applied to IoT platform (Ghosh, 2016). Firstly, user control and freedom allow user to select an optional function to exit such as pop up alert while sensor devices is detecting an emergency value. The next one is match between system and the real world, the good design for IoT platform is to understand what users' expectation is by collecting data to analyze.

D. Chi Square

In analysis phase, the second usability testing will be used the same factors from the beginning phase to compare between the result of version 1.0 and newer version 2.0 by using Chi-Square statistical method (1). The Chi Square can test in different value in various measurement scale. Moreover, there are some more benefit about Chi square test is used to determine statistically important difference frequencies value between the expected and the observed. It can be group in one or more categories.

$$X^2 = \frac{n(ad-bc)^2}{(a+b)(c+d)(a+c)(b+d)} \quad (1)$$

This research is focused on two sample test group (high satisfaction and low satisfaction score) based on the output of significant usability heuristic testing factors. The result table will be discussed in the next section.

In terms of the evaluation process, it can be shown in figure 4. The overall process divided in three phases, UX/UI finding factor improvement, analysis and future works. The chi-square statistic method has been chosen within this analysis phase.

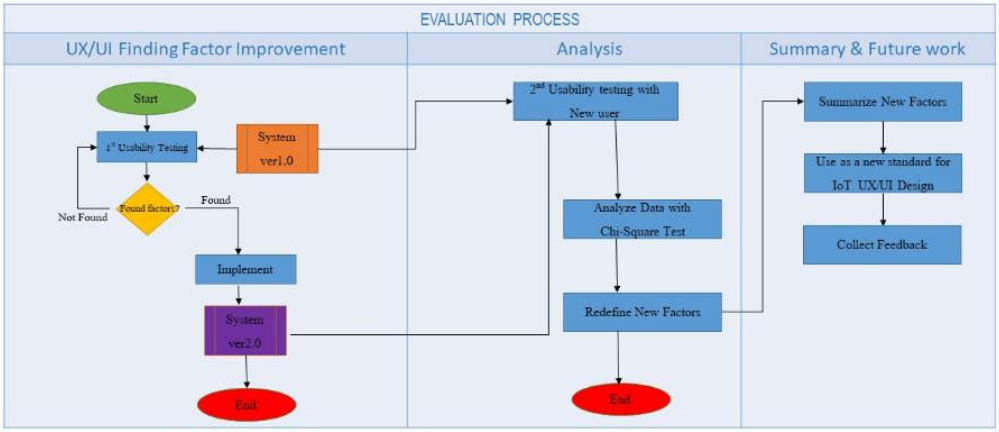

Figure 4 Evaluation research flow

At an initial phase of finding factor for improvement in figure 4 had been taken around 2 months to find out all weak points of UX/UI with a survey questionnaire usability testing method. Usability testing question has been tested with researcher in laboratory animal research center base on 10 usability heuristic.

After the researcher found out significant factors from the IoT platform version 1.0. The designer has been redesigning the system from usability guideline and transfer to the developer team to implement into the second version 2.0.

RESULT AND DISCUSSION

In this section will be shown the comparison chart between researcher's feedback in system version 1.0 and version 2.0 with an open-ended survey questionnaire. The open-ended question created within a boundary of 10 usability heuristics (u1-u10) for UI Design. Each section contains two question with score range 1 to 5 of users' satisfaction. However, there are various factor to discuss in lowest/highest score. More information will be considered in sections below:

According to the first result from 10 researchers with the system version1.0 in figure 5 at laboratory animal research center (LARC), the system has been tested inside a building almost a year before collected data.

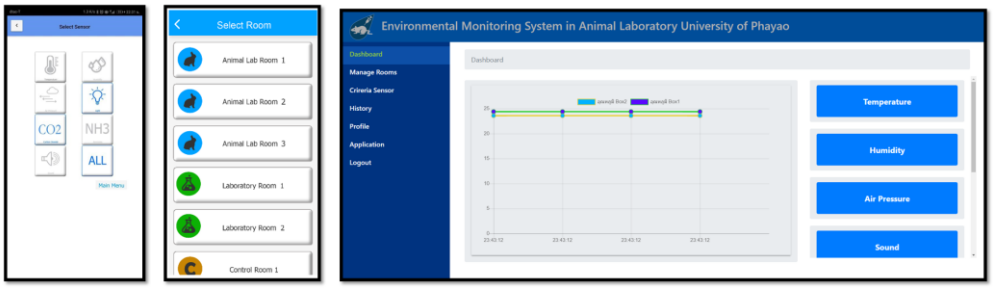

Figure 5 System Design version 1.0

The two similar majority points to noted that are “error prevention checklist” (u5, 12%) and “Recognition rather than recall” (u6, 12%) as shown in figure 6.

Researchers	No	Feedback Score									
		u1	u2	u3	u4	u5	u6	u7	u8	u9	u10
10	1	6	4	5	6	8	6	8	7	9	5
	2	8	5	7	7	9	8	8	6	8	7
	3	10	3	6	7	10	8	9	8	6	9
	4	7	5	3	6	8	8	7	8	6	10
	5	6	6	5	7	7	10	6	7	5	10
	6	4	4	3	6	8	8	10	5	6	8
	7	6	4	8	5	10	7	6	8	8	8
	8	7	7	5	5	7	9	8	9	7	7
	9	6	4	5	10	8	8	7	9	6	5
	10	10	6	5	7	5	9	8	8	6	7
Total Score		70	48	52	66	80	81	77	75	67	76
Percentage		10%	7%	8%	10%	12%	12%	11%	11%	10%	11%

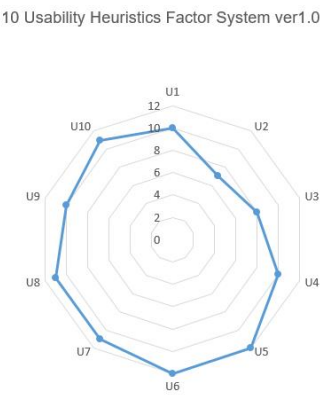

Figure 6 The overall result from 10 researchers with version 1.0

However, there are some minority factors shown the result at “Match between system” and “the real world”, (u2, 7%) and “User control and freedom”, (u3, 8%) respectively. After summarize in the first result, the front end developer and UX/UI designer had been redesign the user interface and user experience to release in the second version. The expectation in a new design is to create new functionalities to resolve a problems u2 and u3 factors.

In the second version in figure 7 has been improved features which are related to u2 and u3. The quality of network signal for each sensor has been create with a sign an icon. The red color will occur while the signal lost or disconnect sensor devices. Moreover, the notification has been upgraded with a red pop up alert when a sensor value hit a peak of over the red line set up from researcher. These two result are correlation with u2 and u3, respectively.

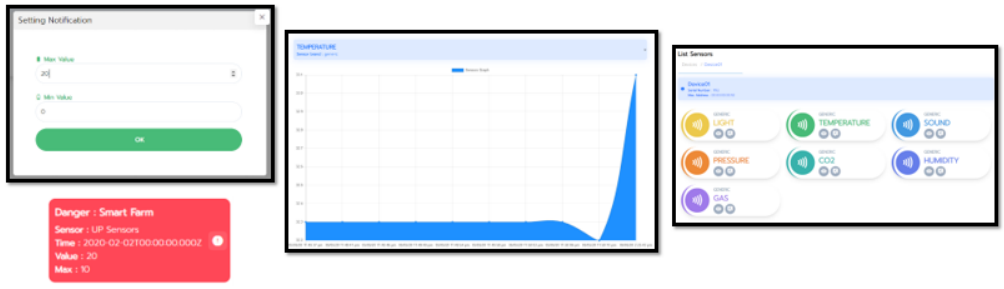

Figure 7 System Version 2.0

The result from the latest version 2.0 shown that the same respondents were given a better user experience with u2, 10% (77) and u3, 11% (80) factor result score. The score is growing up from the previous version 3% for both as shown in figure 8. The better result of UX in version 2.0 give an overall usage more quality and more usability at 1 % (u5 to u9).

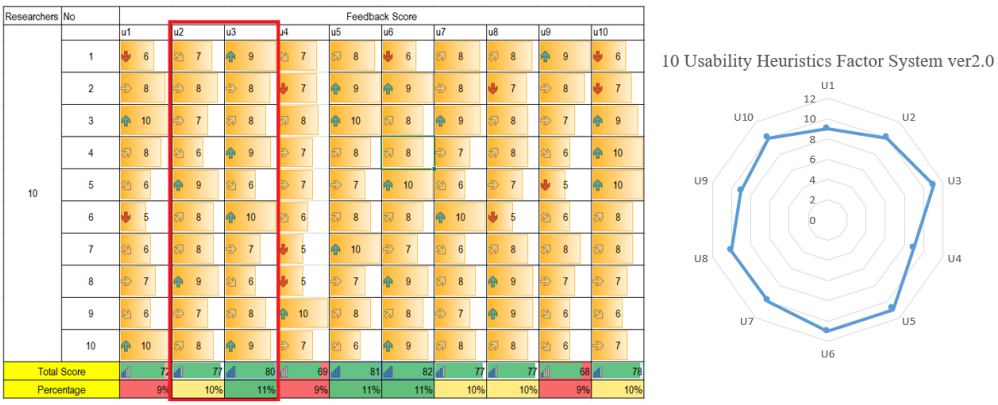

Figure 8 The overall result from 10 researchers with version 2.0

Table 2 Comparison feedback evidence

Neilson's laws IoT Platform Factors	Feedback Evidences	
	System version 1.0	System version 2.0
Match between system and the real world	"It's hard to find a right button" "There are some icon images are not related to their information"	"Easy to find an add device button" "Icon logo are make sense to me" "Use of color such as red for notification when sensor value over limit is perfect"
User control and freedom	"The system allows me to add a wrong id device" "Why the system can delete my device easily" "I delete device by mistake and the system won't bring it back"	"Pop up alert help me not to dump device" "It's good that system can detect a wrong ID and the same ID" "Perfect, The system is not allow to add a wrong device"

I. Match between system and the real world

In this section the minority comment feedback point to a design of icons on system version 1.0, table 2 indicated as "It's hard to find a right button". The system

version 1.0 contains small and mismatch buttons such as menu and back buttons. These drawbacks were effect the experience of using real-time report sensor value which is the main feature.

Finally, the system version 2.0 has been improve all the comment with a clear view button with a sense of logo icon as show in figure 8. Moreover, the color experience such as red color has been used as warning notification for aggressive response. The evidence supported that user gained better experience as the feedback indicated “Icon logo are make sense to me” and “Use of color such as red for notification when sensor value over limit is perfect”.

II. User control and freedom

There is some negative aspect about accidental pressing button as mentioned “Why the system can delete my device easily” and “The system allows me to add a wrong id device”. According to users ‘comment can be seen that the system version 1.0 were missing a feature to find the way to exit of system for user when they face an accidental situation such as delete function. Another mistake about previous system is that the wrong device id should not allow to add to the system because each NB-IoT board contains their unique id.

The current version 2.0 resolved issues by implementing a pop-up alert message with optional button when user accidentally delete device. Another improvement is the device identification detection. The system will display a warning message as” Wrong id” when it detects a wrong id input from user so that user should know the correct id to create their own device to see all real-time environment report. The new feedback result can be guaranteed that users were getting better experience such as “Pop up alert help me not to dump device” and “It’s good that system can detect a wrong ID and the same ID”

In Chi Square test used two sample test (satisfied and not satisfied cross software version 1.0 and 2.0, respectively) as shown in table 2. The null hypotheses (H_0) are stand for no relation between 10 usability heuristic and UX/UI for IoT. In another hypotheses (H_1), there are some evidence shown relationship between 10 usability heuristic and UX/UI for IoT. Degree freedom is equals 1 (df = k-1, k = 2 sample test) and marked on table of Chi square at 0.05 is 3.841.

Table 3 The result of user’s contentment in UX/UI

Groups	Satisfied	Not Satisfied	Total
Version 1.0	2 (a)	8 (b)	10 (a+b)
Version 2.0	9 (c)	1 (d)	10 (c+d)
Total	11 (a+c)	9 (b+d)	20 (n)

In Chi square equation test above (1) calculate the score is 9.8989 from the result shown in table 3. This result is greater than the standard score table of Chi square. It can be clearly seen that the optional hypotheses (H_1) is accepted at the

significance level 0.05. From an overall result H_1, there are some relation factors between 10 usability heuristic and UX/UI.

CONCLUSION

From an overall perspective, there are two majority research's objectives. First objective is to find out significant factor to improve UX/UI for IoT platform based on Jakob Nielsen's 10 usability heuristic. This research supported by researcher's team at laboratory animal research center (LARC), University of Phayao. The data has been collected from 10 respondents (version 1.0 and version 2.0, 10 respondents) with a different test period of time.

The result represented as two significance factors out of ten, "Match between system and the real world" and "User control freedom". Another majority point is to ensure that two Nielsen's factors are related to IoT UX/UI improvement. The result from Chi-square also supported that there is relation between two Nielsen's factor and IoT platform design for users to receive a better user's experience. To conclude that IoT platform should design system as a human being to understand and communicate to people in their own environment as mentioned in U2 Nielsen's law. Another suggestion is about to reduce human error by an accidental. The system should detect when user is going on the wrong track and notice users to come back to their current position. Lastly, this research is another useful resource for future study to find out appropriate design factors for IoT platform when business and technology are change.

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REFERENCES

Barnum, C. M. (2010). *Usability testing essentials: ready, set... test!*. Elsevier.

Chotisarn, N., Plengvittaya, C., Sanpote, D., & Ratchakom, M. (2016). Usability Heuristic Evaluation for Phayao Province E-Government Portal, Thailand. *NU. International Journal of Science*. ***13*(1)**, 8-16.

Crumlish, C., & Malone, E. (2009). *Designing social interfaces: Principles, patterns, and practices for improving the user experience*. " O'Reilly Media, Inc.".

Dumas, J. S., Dumas, J. S., & Redish, J. (1999). *A practical guide to usability testing*. Intellect books.

Galitz, W. O. (2007). *The essential guide to user interface design: an introduction to GUI design principles and techniques*. John Wiley & Sons.

Ghosh, A. M., Halder, D., & Hossain, S. A. (2016, May). Remote health monitoring system through IoT. In *2016 5th International Conference on Informatics, Electronics and Vision (ICIEV)* (pp. 921-926). IEEE.

Gothelf, J. (2013). *Lean UX: Applying lean principles to improve user experience*. " O'Reilly Media, Inc.".

Halstead, S., Serrano, H. D., & Proctor, S. (2015). Finding top ui/ux design talent on adobe behance. *Procedia Computer Science*. ***51***, 2426-2434.

Khast, P. (2017). UX/UI Design Process for a Peer to Peer Financial Platform.

Lodhi, A. (2010, October). Usability Heuristics as an assessment parameter: For performing Usability Testing. In *2010 2nd International Conference on Software Technology and Engineering* (Vol. 2, pp. V2-256). IEEE.

Manisha, R., & Shraddha, M. (2016). Usuability heuristic Redefined for IoT Based Interfaces. *VNSGU JOURNAL OF SCIENCE AND TECHNOLOGY*. 5(1), 99-103.

Nielsen, J. (1994, April). Enhancing the explanatory power of usability heuristics. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (pp. 152-158).

Paz, F., & Pow-Sang, J. A. (2016). A systematic mapping review of usability evaluation methods for software development process. *International Journal of Software Engineering and Its Applications*. ***10*****(1)**, 165-178.