Analysis of Cardinal EDGE Usability Using Different Technological Devices

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Abstract

This study aims to provide an insight on the usability of Cardinal EDGE using the top three most used gadgets such as laptop, mobile and tablet. An AHP analysis was conducted on a data set collected a survey data collected through online questionnaires from an unpublished research paper from 261 respondents from a population of Senior High School STEM students enrolled at Mapua University. AHP analysis was used to identify the effectiveness and usability of the three gadgets relevant to the five main criteria and fifteen sub-criteria. Results showed Learnability (0.484) with the highest priority weight followed by User Interface (0.410), Flexibility (0.302), User Satisfaction (0.139) and Design and Layout with 0.039. Synthesis results showed that with respect to the User Interface, the alternative that has the highest score is the Laptop (0.374) but relative to the Flexibility, Tablet (0.575) is most preferred. As for the Design and Layout, the Mobile got the highest score (0.635) but for Learnability, Tablet and Mobile (0.474) got the same score. User Satisfaction has Laptop as its most preferred device with a score of 0.655. Finally, with respect to the Goal, Tablet has the highest score (0.458) against Laptop (0.191) and Mobile (0.352).

Keywords
Analytic Hierarchy Process, Learning Management System, Cardinal Edge, Technological Gadget

1 Introduction
The progress of modern technology is developing the way we work, play, create, and communicate. With this advancement, it also helps in creating new educational opportunities in the digital world. Higher institutions consider changing their conventional way of teaching to online based as it allows their students to finish their education anywhere in the world without having any interference in their academic journey (Reid, 2019). Administering a well-run flow of knowledge in an academic institution is one of the many ways to improve academic standards and guarantee quality. With the rising of education technology, access to information and communication have been made easier and trouble-free. Through modern technology and the internet, information circulates fast across the globe which makes the Learning Management System (LMS) an essential instrument for students in order to stay updated with their daily school activities (Adzharuddi & Ling, 2013). LMS uses technology to offer learning materials for students in any location. Overall, the concept of LMS can be arranged in relationship to e-learning, technocentric (use of mobile devices in education), providing formal education (face-to-face learning), and centered on the students' perspectives (Derakhshan, 2012). LMS is correlated with communication technology, therefore it is device-dependent (Gong & Wallace, 2012).

1.1 Objectives
Although numerous research have been conducted to examine the usability and user interface of Blackboard Learn, it is important to address that most of the previous studies focused more on the website application using a desktop rather than the mobile application using mobile devices. In this paper, the researchers will address and provide a comparison of the usability of Cardinal EDGE using different gadgets such as laptops, tablets, and mobile phones. An analysis of the effectivity of Cardinal EDGE features in terms of User Interface, Flexibility, Design and Layout, Learnability and User Satisfaction will be conducted. The primary purpose of this study is to compare the effectiveness and usability of different technological devices such as mobile phones, tablets, and laptops. Moreover, the authors also aim to identify the significant factors affecting the students' satisfaction.

2 Literature Review

As the need for mobile learning arises, many Learning Management Systems (LMS) have already been available for institutions to apply in their education. With this, many studies have been conducted to analyze the usability of gadgets in mobile learning. This section discusses concepts and related studies pertaining to LMS and technological gadgets.

2.1 Learning Management Systems (LMS)

Learning Management Systems (LMS) is an internet-based, multi-user software application that allows meeting and collaboration of instructors and students in a certain organization or institution. It involves the utilization of digital instruments for teaching and learning. Other LMS may include discussion boards, built-in authoring tools, and more. It has become an essential part of modern educational systems of various universities because of the interactive features it offers (Pishva et al., 2010). Table 1 shows some of the top LMS in 2021 according to (Enfroy, 2021).

S. No.	Name
1	TalentLMS
2	LearnDash
3	SkyPrep
4	Academy of Mine
5	Docebo
6	Blackboard
7	Moodle
8	JoomlaLMS
9	Adobe Captivate Prime
10	SAP Litmos LMS

Table 1. Top 10 LMS of 2021

2.2 Blackboard Learn

Blackboard Learn, developed by Blackboard Inc., is one of the most common web-based Learning Management Systems that provide a curriculum-oriented platform designed for students and instructors (Alghafis et al., 2020; Jamal & Shanaah, 2011; Majooni et al., 2018). On their website, Blackboard Inc. (n.d.-a) described Blackboard Learn as a modern, intuitive, and fully responsive interface that goes beyond the traditional LMS by providing a simpler, more powerful teaching and learning experience. It also allows active engagement between students and their instructors through communication and collaboration, as well as a means for providing easy access to students to all types of information and learning materials. In the international context, Blackboard Learn is also adopted by some schools in Malaysia, Saudi Arabia, South Africa, Sweden, and the USA, as evident from previous studies which focused on the usability and accessibility of Blackboard Learn (Alelaiwi & Hossain, 2015; Alturki et al., 2016; Jamal & Shanaah, 2011; Majooni et al., 2018; Moonsamy & Govender, 2018; Squillante et al., 2014).

Feature	Description
Managing Information	Managing and storing personal information, such as changing passwords and determining privacy options. It also has a calendar to record schedules, to-do items, and other important dates.
Accessing Course Materials	Access to a variety of course materials, such as online lectures, tests, assignments, multimedia, and links to websites and social media.
Communication	Instructors may also communicate with their students through Blackboard Collaborate, discussions, course messages, and announcements.

Submitting Assignments and Tests	Assignments and files can be easily uploaded and received back together with a grade and feedback from the instructor.
Checking Grades	Students can view all grades from all activities either for one course at a time or for all the courses in one page. Instructors can also leave feedback for submissions, which can also be seen by the students once their work has been given back.
Blackboard Mobile App	Initially launched in 2015, the Blackboard mobile app is specially designed for students to view content and participate in courses readily available through iOS and Android mobile devices.

Table 2. Blackboard Learn Features

2.3 Mapua Cardinal EDGE

Mapúa University adopted the use of Cardinal EDGE, an LMS powered by Blackboard, as its main platform for online learning. Together with the University of Santo Tomas, Mapúa University and its sister schools are only some of the institutions in the Philippines which utilize Blackboard as an LMS (Abisado et al., 2020; Mapúa University, 2017). Cardinal EDGE or Education in a Digital and Global Environment, is "part of the University's commitments in developing and bolstering its world-class quality of education, reaching more learners locally and across the globe through its online learning space" (Mapúa Digital Academics, 2019, "What is Mapúa Digital Academics?", para. 1). As it is powered by Blackboard, it also has the same features with the exception of some additions.

Mapúa University (2020b) stated that the featured tools in Blackboard Learn are complemented by huge electronic databases of educational materials through Cardinal EDGE. Similar to Blackboard Learn, Cardinal EDGE can also be accessed through other devices such as laptops or desktop computers, tablets, or mobile phones (Mapúa University, 2020a).

Feature	Description
Mapúa E-Text Infinity Solution (METIS)	METIS is an e-library of e-textbooks. According to Mapúa University Admissions Office (2020), there are more than 11,000 e-textbooks available for access to students.
Digital Learning Solutions	These consist of Cengage and Wiley Plus platforms which offer great fun in learning. These have the capacity to engage students and make learning interactive. Wiley Plus and Cengage feature digital resources such as recorded lectures, references, modules, and course assessments.
Panopto	Panopto is a lecture capture and video management software with a rich virtual classroom experience used to deliver learning content to students.
Coursera	Coursera is a worldwide online learning platform that offers access to 4300 courses and micro-credentials from 200+ globally recognized organizations, companies like Google and IBM, and institutions such as Yale and Stanford. Through Coursera, students can increase their academic opportunities (Mapúa University, 2020b).
Blackboard Collaborate Ultra	Blackboard Collaborate Ultra provides a simple and reliable virtual classroom used to conduct online classes that can be recorded by the instructor then accessed and downloaded by students (Boncolmo & Mateo, 2020).
Blackboard Mobile App	Initially launched in 2015, the Blackboard mobile app is specially designed for students to view content and participate in courses readily available through iOS and Android mobile devices.

Table 3. Cardinal EDGE Features

2.4 Technological Gadgets/Devices

Technology plays an increasingly important role both in traditional education as well in other fields that use technology for academic purposes. The use of devices remain very convenient for students and teachers because they use it for collaboration, communication, creation, and access to different platforms. Some of the common devices that are being

used by the institutions are software, apps, learning management systems, e-books, desktop and laptop, tablets, smartphones, and many more (Mohseni, 2014).

2.4.1 Tablets

Tablets are a modern technology that features touchscreen technology, increased portability, connection to Wi-Fi, and an intuitive user interface. They are a great for being very light and very convenient to bring around as it allows the students to access their online course materials efficiently. Another great feature of the tablet is the touchscreen display which can make the learning of students interactive and engaging. Being more portable due to its smaller size is the notable feature of tablets. However, unlike mobile phones the popularity of tablets in education is gradually rising due to its following features: 1.) high-quality screen that is suitable for reading experiences, 2.) interactive e-books and educational games, 3.) easy access to Learning Management Systems, 4.) note-taking experience, 5.) video streaming and surfing the web, and 6.) making presentations and e-mail.

2.4.2 Laptops

Laptops are designed after a desktop computer because it uses the same features with a desktop computer. The most common operating systems in laptops are Windows and Linux (Sarsar et al. 2019). One of the advantages of using laptops from other devices is having more software due to its powerful processors. Possessing a powerful processor makes the tasks and activities in the laptop operative and responsive (Mohseni, 2014).

2.4.3 Mobile Phones

Mobile phones are compact devices that are used to message other people instantly. Additionally, it can be an IOS or Android operating system (Ghaznavi et al., 2011). In today's generation, mobile phones support calendar, planner, camera, notes, internet resource, entertainment system, and audio-video features, because of that it became a high-tech mobile computer with an operating system that can support all applications, especially educational applications (Keengwe, Schnellert & Jonas, 2014). For being a portable device, it allows individuals to utilize their digital mobile phones as tools, and not just only for entertainment purposes. Mobile phones can be used for educational purposes, namely for messaging, recording class sessions, or taking quick pictures of the board (Mohseni, 2014).

Table 1 shows a summary of published studies conducted relevant to finding relations between LMS and related technological gadgets used.

Author(s)	Research Findings
Kraleva et al. (2019)	LMS that are adapted by institutions vary in usability and functionalities and may also vary depending on the device used.
Fleur et al (2018)	Reported that mobile applications are better even though only the scale of attractiveness and novelty of them is higher than desktop applications. Only the scale of dependability is surpassed by web applications.
Costley (2014)	Another research states that technology integration in public and private schools has the following advantages: increased in student's motivation, collaboration, learning opportunities, self-esteem, and technology skills.
Emelyanova and Voronina (2014)	Provided statistics on which they concluded upon that academic institutions should take the next step and further innovate their educational systems.
Holmström and Pitkänen (2012)	Results show that majority of their respondents agree that electronic learning gives way to new and efficient teaching methods.
Kinash et al. (2012)	Results indicated that the respondents used their mobile devices more for non-educative purposes and that the concept of learning is not deemed strong in mobile learning.
Stritto and Linder (2018)	The results of the study showed that tablets and smartphones are being used by some of the students to access their learning materials for convenience, but they were rarely chosen for engaging with in-depth learning. However, the main results implied that laptops are preferred by the students and teachers to access their learning management systems and other multimedia platforms.
Gong and Wallace (2012)	Laptops, among all the other technologies used in e-learning, are the most preferred and common device used by students. Even so, a large number of students still prefer using and learning using an iPad.
Abisado et al. (2020)	Data showed that approximately 25,000,000 users across the world use Blackboard Learn which includes University of Santo Tomas and Mapúa University in the Philippines.
Alelaiwi and Hossain (2015)	Results from their study showed that both participants had drawbacks on the user interface and the majority agreed that Blackboard did not have stable navigation. Nonetheless, both participants were satisfied with the effectiveness of the Blackboard course content and tools.

Author(s)	Research Findings
Alghafis et al. (2020)	Results from this study showed that with regards to interface design and overall usability, Moodle is more interactive, organized, and has better features than Blackboard Learn.
Squillante et al. (2014)	Blackboard is outstanding at presenting class content; students are secured with their data and are overall satisfied with the user experience although they also believed that Blackboard did not help them learn and that it was neither easily accessible using mobile devices nor allowed effective collaborative sessions online
Moonsamy and Govender (2018)	These studies proved that the Blackboard interface is not user-friendly and difficult to use, which is possibly why some resort to using alternative LMS.
Kinash, Brand, and Mathew (2012)	The finding of the study stated that mobile learning is efficient to the students for being an all-in-one place that can be easily used by different learners who are on-the-go.
Uther (2019)	Mobile learning is focused on the ease and flexibility of students in learning rather than the mobility of devices. The "just-in-time" learning phrase has been highlighted, as it gives ease and rapid access to mobile learning.

Table 4. Summarized Literature Review on LMS, Various Platforms and Technological Gadgets

3 Methods

3.1 Data Source

Survey data were collected through questionnaires between January 16 and January 24, 2021. Participants were recruited through the researchers' social network platforms. The research data was collected from 261 respondents from a population of 750 Senior High School STEM students enrolled at Mapua University - Intramuros of the present academic year, 2020-2021. Using Slovin's formula, the researchers calculated a sample of 261 was required. The Slovin's formula and how the sample is calculated are given below:

$$n = \frac{N}{1 + Ne^2}$$

3.2 Questionnaire Design

The questionnaire consisted of demographic profile questions (Binyamin et. al 2017) and questions sourced from various related studies such as the System Usability Scale (SUS) (Brooke 2013), etc.

The questions were answered by scoring each question between 1 to 5 with 1 as Very Dissatisfied and 5 as Very Satisfied. Answers were dependent on which device the respondents most frequently use. The participants were grouped into three categories depending on which device they most frequently use in accessing Cardinal EDGE. Given the sample size of 261 respondents, the target participants per category (mobile, tablet, laptop) is at least 50 STEM students each. After categorizing, the participants of each group were then provided with the link to the exact copy of the usability questionnaire. Information included were the participants' gender, age, section, and academic standing. Generally, participants were able to complete the questionnaire within 10-15 minutes. Questionnaire sample can be found in Appendix A.

3.3 Development of Model

The research used a combination of basic computation of mathematical mean/average, statistical computations, and an advanced technique such as Analytic Hierarchy Process (AHP). All calculations were done using Microsoft Excel as well a special software called Expert Choice for AHP calculations. Calculation was done by calculating the average of section values. Average scores are shown on Table 5-7.

Main Criteria	User Interface	Design and Layout	Flexibility	Learnability	User Satisfaction
Average Scores	3.54	3.91	3.52	4.01	3.76

Table 5. Average – Main Criteria

Sub-Criteria	Menu Bar	Link to Main Page	Message Notification	Error Tolerance	System Terminologies	Overall Interface	Clear Font	Organization of Materials	Consistency	Download and Upload Service	Page Load Time	Effective Collaborative Discussion	Accessibility	Ease of Learning	User Satisfaction
Average Scores	4.18	3.40	3.07	2.92	4.14	3.95	4.32	3.80	3.82	3.64	2.85	3.64	3.84	4.01	3.76

Table 6. Average – Sub-Criteria

Alternative	Menu Bar	Link to Main Page	Message Notification	Error Tolerance	System Terminologies	Overall Interface	Clear Font	Organization of Materials	Consistency	Download and Upload Service	Page Load Time	Effective Collaborative Discussion	Accessibility	Ease of Learning	User Satisfaction
Laptop	4.17	3.43	3.14	2.97	4.14	3.94	4.31	3.72	3.82	3.92	2.93	3.41	3.75	3.98	3.81
Mobile	4.02	3.31	2.90	2.73	4.14	3.97	4.43	3.93	3.80	3.09	2.72	3.83	3.86	4.07	3.59
Tablet	4.36	3.38	2.97	2.83	4.07	3.93	4.25	3.98	3.82	3.21	2.69	4.25	4.14	4.07	3.75

Table 7. Average – Sub-Criteria across Alternatives

Pairwise Comparison calculation and mapping is done by converting the average values to match the Saaty Scale which is compatible to the scale used in Expert Choice. This is done by using the maximum value of difference between pairs per criteria and divided into 9 to distribute the values to assign a value from 1 to 9.

3.4 Graphical Results

AHP results were computed using manual and Expert Choice simulations which an overall inconsistency value of 3% which less than the 10% acceptable value. This shows that the results obtained are considered to be consistent.

3.4.1 Priority Weight Values (Alternatives)

	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise
Alternative	User Interface Menu Bar (L: .329)	User Interface Link to Main Page (L: .072)	User Interface Message Notificatior (L: .036)	User Interface Error Tolerance (L: .026)	User Interface System Terminologies (L: .329)
Laptop	.261	1.000	1.000	1.000	1.000
Mobile	.085	.079	.084	.080	1.000
Tablet	1.000	.281	.189	.231	.111

	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise
Alternative	User Interface Overall Interface (L: .208)	Flexibility Download and Uploa Service (L: .264)	Flexibility Page Load Time (L: .038)	Flexibility Effective Collaborative Discussion (L: .312)	Flexibility Accessibility (L: .386)
Laptop	.210	1.000	1.000	.079	.084
Mobile	1.000	.092	.111	.281	.189
Tablet	.088	.151	.111	1.000	1.000

	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise
Alternative	Design and Layout Clear Font (L: .818)	Design and Layout Organization of Materials (L: .091)	Design and Layout Consistency (L: .091)	Learnability Ease of Learning (L: 1.000)	User Satisfaction User Satisfaction (L: 1.000)
Laptop	.189	.092	1.000	.111	1.000
Mobile	1.000	.606	.111	1.000	.084
Tablet	.084	1.000	1.000	1.000	.442

Figure 1. Main Criteria/Sub-Criteria Weight Values

3.4.2 AHP Values

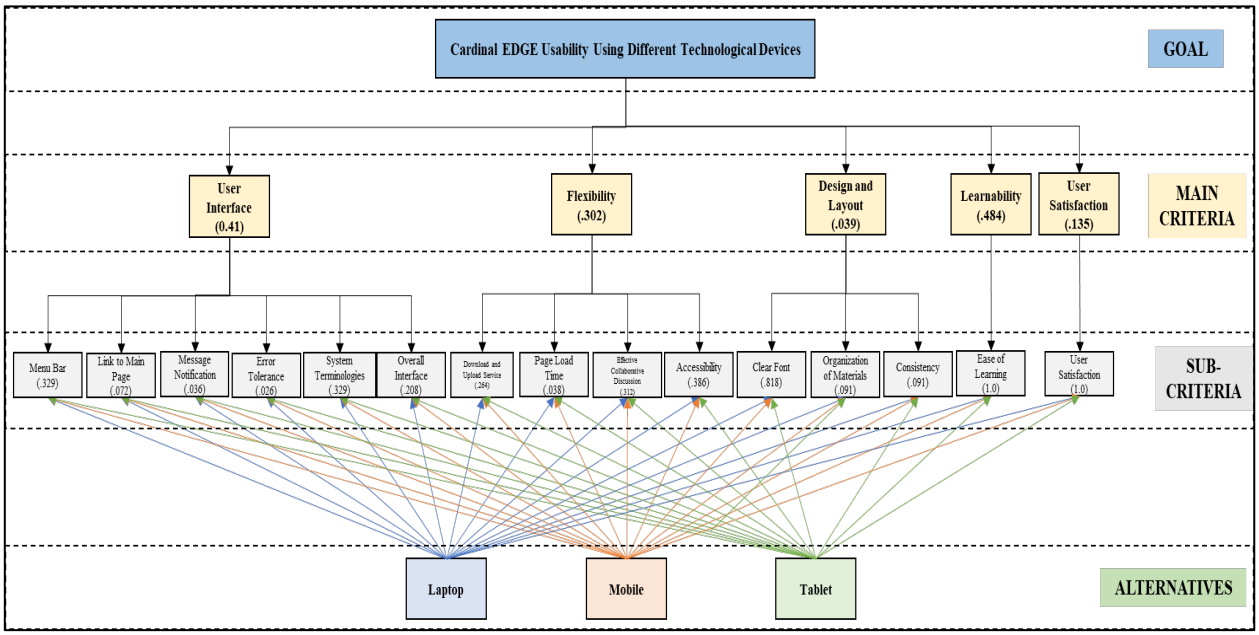

Figure 2. AHP Model with Values

3.4.3 Synthesis Results (Main Category vs. Alternatives)

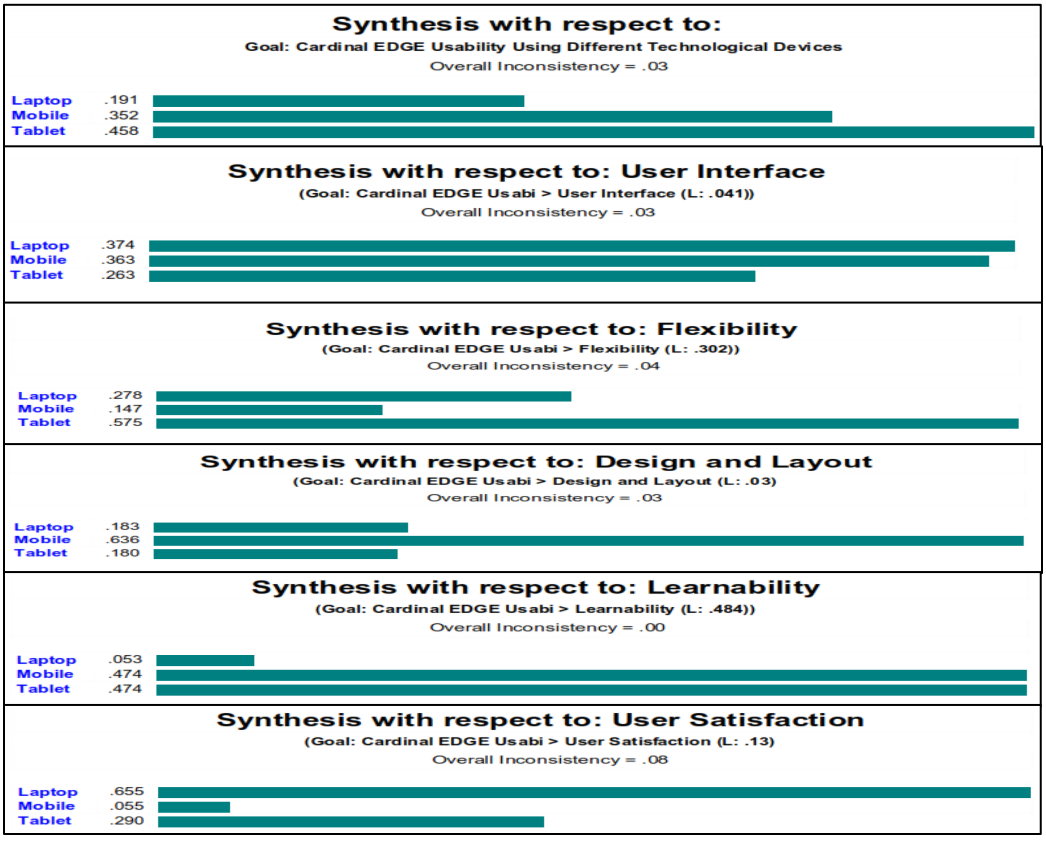

Figure 3. Synthesis: Goal, Main Criteria: User Interface, Flexibility, Design and Layout, Learnability and User Satisfaction

3.4.4 Dynamic Sensitivity Graphs

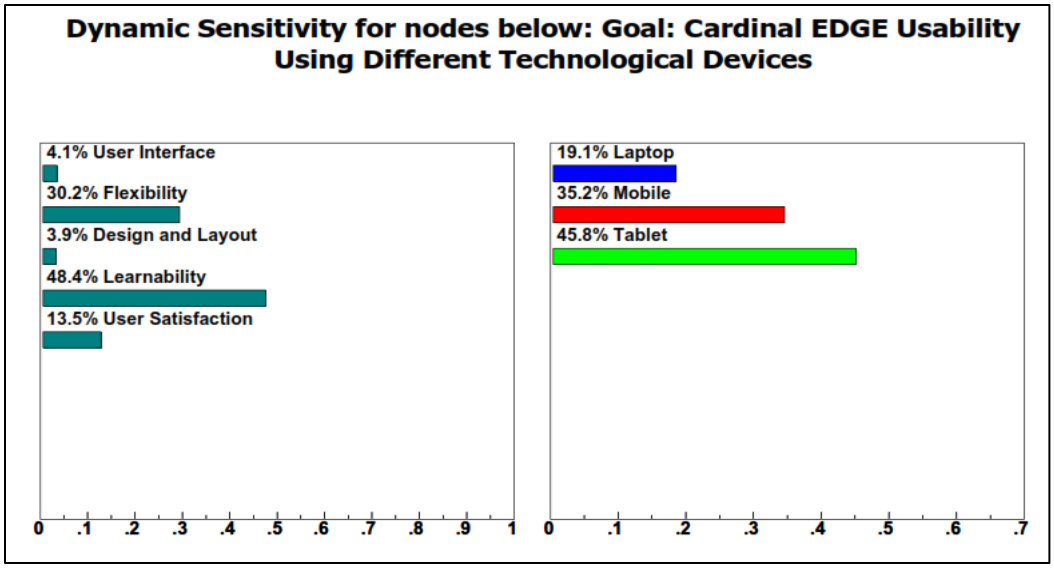

Figure 4. Main Criteria/Sub-Criteria Weight Values

3.4.5 Gradient Sensitivity Graphs

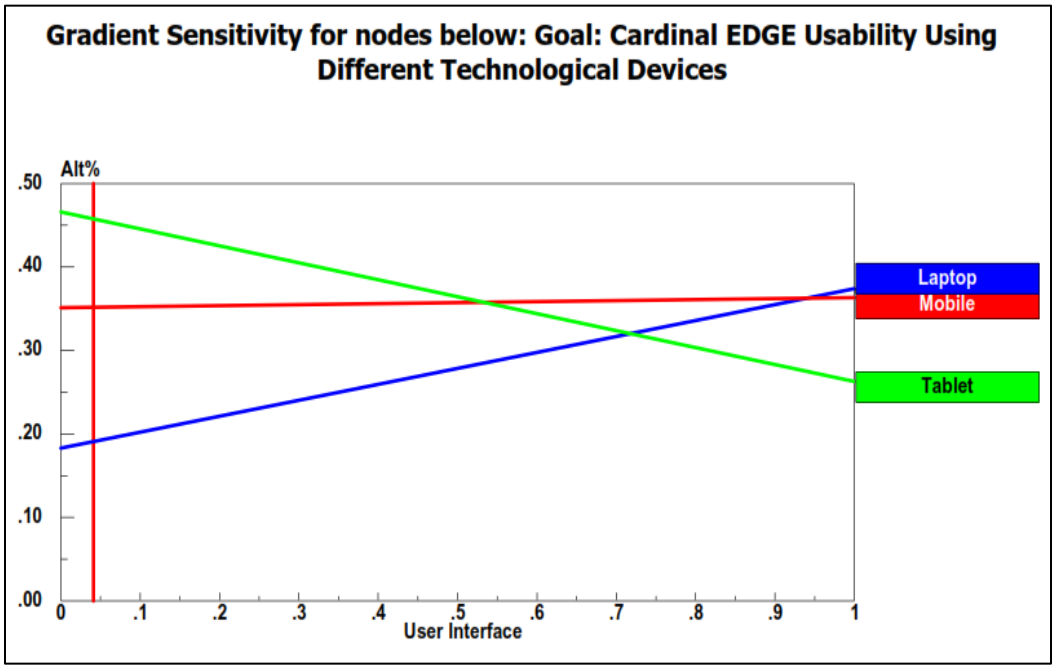

Figure 5. Main Criteria/Sub-Criteria Weight Values

3.4.6 Performance Sensitivity Graphs

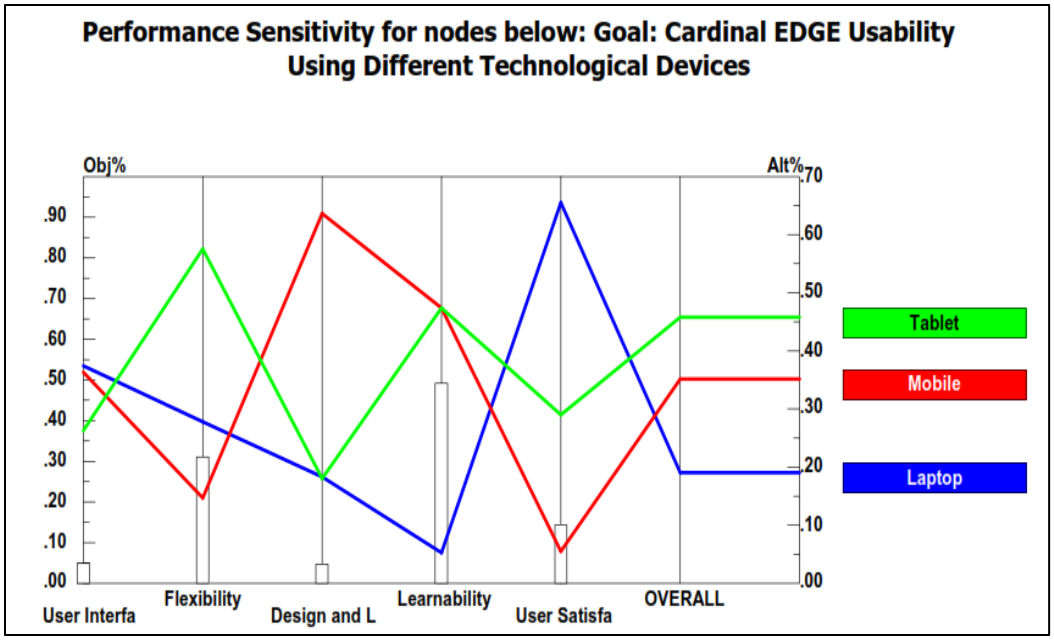

Figure 6. Main Criteria/Sub-Criteria Weight Values

3.4.7 Weighted Head-to-Head Between Laptop and Mobile

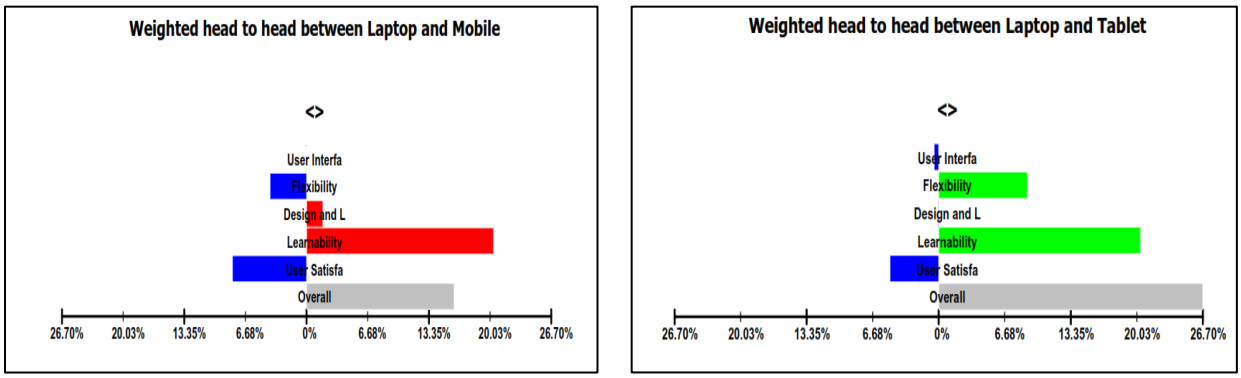

Figure 7. Weighted Head-to-Head Between Laptop and Mobile / Laptop and Tablet

4 Conclusion

Looking at the results of the synthesis, it is revealed that with respect to the User Interface, the alternative that has the highest score is the Laptop (0.374) followed by Mobile (0.363) and Tablet (0.263). relative to the flexibility, Tablet is most preferred with the score of 0.575. As for the Design and Layout, the Mobile got the highest score (0.635). For the Learnability, both Tablet and Mobile are most preferred with a score of 0.474. User Satisfaction has Laptop as it is most preferred device with a score of 0.655, followed by Tablet (0.290) and Mobile (0.55). Finally, with respect to the Goal, Tablet has the highest score with 0.458 against the Laptop (0.191) and Mobile (0.352).

As shown in the results, the highest priority weight is given to the main criteria Learnability (0.484) which is not very far from the value given to User Interface (0.410). Flexibility received a priority weight of 0.302 followed by User Satisfaction with 0.139. The least priority score was given to Design and Layout with 0.039.

Among the sub-criteria, for User Interface, Menu Bar is the highest with 0.329 and Message Notification as the lowest (0.072). As for the Flexibility, Accessibility (0.386) is the most important while Page Load Time is the least important (0.038). Design and Layout has Consistency and Organization of Materials as the most important with both getting priority weights of 0.0910. Clear Font got a score of 0.818.

The study revealed that considering all the evaluating factors, the Tablet has been identified as the most usable device in accessing Cardinal EDGE. The next most effective device is the mobile followed by the laptop preferred device for Cardinal EDGE.

It is a surprising result since it is automatically assumed that the Laptop will get the best score among the three alternatives. But clearly, in the results, the Tablet is the best device to use mainly due to its high scores in terms of Flexibility and Learnability.

The case is the same for the Mobile, giving it a rank of second place.

Surprisingly, the Laptop placed last according to the results obtained. Although the Laptop has been consistently high in the User Interface and User Satisfaction, it has very low scores in the Learnability, Design and Layout, and Flexibility. With most Tablets nowadays having similar capabilities with a Laptop, the Flexibility of the Tablet gives it a higher rank than the Laptop.

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