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ADVANTAGES AND CHALLENGES OF TABLET PC'S USAGE

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Abstract: In this study we were interested in evaluating tablet PC device performances, as well as how the respondents perceived its usability. Usability of this kind of device is furthermore investigated in comparison to the other similar mobile devices. The Technique for Order Preferences by Similarity to an Ideal Solution (TOPSIS) is specifically implemented and its outcomes are compared with the calculated System Usability Scale (SUS) scores. One of the TOPSIS method advantages is its ability to identify the best alternative quickly and precisely, which is also one of the most important features of SUS scale.

Keywords: Tablet PC, Mobile Devices, TOPSIS, MADM, SUS, Usability.

MSC: 97C40, 91F99, 91E45, 91C05, 91B08, 90B06, 62P25, 62P30.

1. INTRODUCTION

In recent years, information management has greatly benefited from advances in Information and Communications Technology (ICT) through increasing the speed of information flow, enhancing the efficiency and effectiveness of information communication, and reducing the cost of information transfer. There has been a shift from e-learning, to m-learning (mobile learning) and now, more recently, the idea of ubiquitous learning. The applications of mobile learning range widely, from high school to university education, as well as corporate learning settings, from formal and informal learning to classroom learning, distance learning, and field study.

Mobile technologies exerting a great influence in the way people communicate and access information (Borcea & Iamnitchi, 2008, Sharples, 2008) [1], [2]. These trends have motivated research in a variety of novel applications in mobile learning over the last decade (Pea & Maldona, 2005, Frohberg, 2009) [3], [4] taking advantage of user and device mobility for facilitating learning across multiple contexts, involving different locations, tasks and modes of interaction among users. Despite the many forms of and increasing services offered by mobile learning, it is still immature in terms of its technological limitations and pedagogical considerations (Traxler, 2007) [5]. Typical examples of the devices used for mobile learning include cell phones, smartphones, palmtops, and handheld computers; tablet PCs, laptops, and personal media players (Kukulska-Hulme & Traxler, 2005) [6]. However, it has been widely recognized that mobile learning is not just about the use of portable devices but also about learning across contexts (Walker, 2006) [7]. Mobile learning has unique technological attributes which provide positive pedagogical affordances. As educators search for the most effective and engaging methods for teaching, many are turning to technology to assist in accomplishing their goals. The integration of multimedia devices applications and activities into the classroom is of particular interests. Education is slowly evolving toward classrooms of Teacher-as-Learning-Partner/Facilitator; that should serve students well in the 21st century. These offerings certainly seem to meet the initial learning criteria of engaging digitally-native students, known as Generation Y or Millennials. These students have grown up in a multimedia and multitasking world and have little problem absorbing information from a variety of media like television, web sites, email, blogs, printed magazines, MP3 players, mobile phones, Instant Messaging clients - often simultaneously. This Millennial lifestyle is often at odds with traditional school-based learning, during which students "are asked to sit and focus on one narrowband issue for 45 minutes" (Apple Computer, 2003) [8].

Two emergent topics in technology-based education are one-to-one computing and mobile computing. The technology that may well best support these kinds of computing is the Tablet PC. There are innumerable benefits for educators and learners while using mobile technologies effectively. Tablet PCs help deliver an engaging learning experience with rich, multimedia digital content. Teachers can deliver curriculum through PPT presentations, Word docs, and spreadsheets and mark up digital class work and homework. A particular advantage lies in saving time and money - instructors can use digital forms, convert digital notes to text without having to retype, and reduce paper, supply, and copying costs, and above all, making them ecologically sustainable devices. Because tablets combine computing power with portability, they have become an attractive choice to replace aging personal computers, especially when considering through their cost calculated to be half that of a standard PC laptop, which is extremely important for the countries with poor economic status.

Ozok et al. [9] note that although a fairly substantial body of research has grown up in the last few years on desktop and laptop usability, very few studies have reported on experiments with tablet PCs. Tablet computers, or tablets, differ from touch screen-equipped mobile phones by having larger screens and thinner structure than other mobile phones in day-to-day use. The most fundamental difference between tablet computers and regular computers relating to usability is the input method. With direct manipulation, users can handle files as icons, dragging and clicking them. Hands-on and tactile experience allows fast learning of the basic functions and gestures such as tap and swipe. Nevertheless, there are some problems with using gestures as an input method: the lack of established standards for gestures and their actions and the developers' ignorance about the universal usability principles (complying also with the new devices) (Norman & Nielsen, 2010) [10]. Gestures are non-standard, imprecise and unrepeatable by their nature as non-verbal communication. Tablet computers have solved this problem caused by a lack of feedback, by integrating elements from the traditional Graphical User Interface (GUI), like icons, menus and help system.

In this study we were interested in how the above mentioned attributes of tablet device impact its practical application, as well as how the respondents perceived its usability, especially in comparing to other similar mobile devices. One of the main goals of this paper is to investigate whether the Table PC devices could be the most appropriate kind of device among the other classes of similar devices, considering the matter of usability and learnability dimensions. To achieve this goal, two methods were used:

- The TOPSIS (Technique for order performance by similarity to ideal solution) method of the multiple attribute decision making (MADM) and
- The SUS (System Usability Scale) as another approach for the usability evaluation.

The paper is organized as follows. In the second section the TOPSIS technique is reviewed and formulae and relations are mentioned, and the SUS scale is described, as well as the logical similarity of these two. The third section presents the field experiment related to the specific usage of Tablet PC device, followed by the results of subjective assessments, which consider the usability of other similar mobile devices. In section fourt, the numerical results given by the TOPSIS method are compared to the evaluations obtained by the SUS scale. Finally, we conclude the article from the perspective of the practical application.

Finally, the article is summarized and conclusions and suggestions for future researches are cited.

2. THE TOPSIS METHOD AND THE SYSTEM USABILITY SCALE (SUS)

2.1. The Multiple Attribute Decision Making (MADM) models

Multi Attribute Decision Making (MADM) models are general models used for evaluating, ranking and selecting the most appropriate alternative among several alternatives. They are based on an algorithmic approach suitable to realize a dynamic selection with multiple alternatives (i.e. various types of devices) and attributes (features, user preferences, etc). Algorithmic approach means that each MADM model has specific ranking procedure defined in step-by-step manner that could be presented as an algorithm.

In general, a MADM problem is formulated as follows: $A=\{A_i, i=1, 2,\dots, m\}$ is a set of a finite number of alternatives which represents the possible kinds of mobile devices (in our case). $C=\{C_j , j=1, 2,\ldots, n\}$ is a set of criteria, which are actually factors of choice, such as the interface features, system characteristics, user preferences, ease of usage, and so on. The weight vector $W=\{w_1,w_2,\ldots,w_n\}$ represents the relative importance of these factors. An MADM problem can be represented by a matrix as shown in Table 1.

Table 1: Matrix representation of the MADM problem

	C_1	C_2	•	•	C_n
A_1	x_{11}	x_{12}	•	•	x_{1n}
A_2	X_{21}	x_{22}	•	•	x_{2n}
•	•	•	•	•	•
•	•	•	•	•	•
A_m	x_{m1}	x_{m2}	•	•	x_{mn}
	w_1	w_2	•	•	w_n

2.2. The TOPSIS method

The Technique for Order Preferences by Similarity to an Ideal Solution (TOPSIS) one of the MADM methods and it was proposed by Hwang and Yoon (1981). The main idea came from the concept of the compromise solution to choose the best alternative nearest to the positive ideal solution (optimal solution) and farthest from the negative ideal solution (inferior solution). Then, choose the best one of sorting, which will be the best alternative [11]. The compromise solution can be regarded as choosing the solution with the shortest Euclidean distance from the ideal solution and the farthest Euclidean distance from the negative ideal solution [11]. The TOPSIS alternative calculation includes several steps:

Step 1: Create the normalized decision matrix. Each element r_{ij} of the Euclidean normalized decision matrix R can be calculated in the following way:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{1}$$

Step 2: Create the weighted normalized decision matrix V. It is calculated by multiplying each column of the matrix R with its associated weight w_i.

$$V = \begin{bmatrix} v_{11} = r_{11} \cdot w_1 & v_{12} = r_{12} \cdot w_1 & . & v_{1n} = r_{1n} \cdot w_n \\ v_{21} = r_{21} \cdot w_1 & v_{22} = r_{22} \cdot w_2 & . & v_{2n} = r_{2n} \cdot w_n \\ . & . & . & . \\ v_{m1} = r_{m1} \cdot w_1 & v_{m2} = r_{m2} \cdot w_2 & . & v_{mn} = r_{mn} \cdot w_n \end{bmatrix} \tag{2}$$

Step 3: Determine positive ideal as well as negative ideal (inferior) solution:

$$A^{+} = \left\{ (\max_{i} v_{ij} \middle| j \in J), (\min_{i} v_{ij} \middle| j \in J'), i = 1,..,m \right\} = \left\{ v_1^{+}, v_2^{+}, .., v_m^{+} \right\} \tag{3}$$

$$A^{-} = \left\{ (\min_{i} v_{ij} \middle| j \in J), (\max_{i} v_{ij} \middle| j \in J'), i = 1,..,m \right\} = \left\{ v_1^{-}, v_2^{-}, .., v_m^{-} \right\} \tag{4}$$

where J={ j=1,2,...,n | j is associated with benefit (positive) criteria } and
J'={ j=1,2,...,n | j is associated with cost (negative) criteria }

Step 4: The distance between alternatives are measured using the m-dimensional Euclidean distance. The distance between each alternative and the positive ideal solution (ideal separation) is:

$$S_i^{+} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^{+})^2} \tag{5}$$

The distance between each alternative and the negative ideal solution (negative-ideal separation) is:

$$S_i^{-} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^{-})^2} \tag{6}$$

Step 5: Calculation of the relative closeness to the ideal solution:

$$C_i = \frac{S_i^{+}}{S_i^{-} + S_i^{+}} \tag{7}$$

Step 6: Rank the preference order. The set of alternatives can be ranked according to the decreasing order of C_j.

2.2. The System Usability Scale (SUS)

The System Usability Scale (SUS) developed in 1986 by Digital Equipment Corporation is a ten-item scale giving a global assessment of Usability, operatively defined as the subjective perception of interaction with a system (Brooke, 1996)[12]. The SUS items have been developed according to the three usability criteria defined by the ISO 9241-11[13]: (1) the ability of users to complete tasks using the system, and the quality of the output of those tasks (i.e., effectiveness), (2) the level of resource consumed in performing tasks (i.e., efficiency), and (3) the users' subjective reactions using the system (i.e., satisfaction). The SUS has been used across a wide range of user interfaces, including standard OS-based software interfaces, Web pages and Web applications, cell phones, landline phones, modem and networking equipment, pagers, Interactive Voice Response systems (IVRs), speech systems, and video delivery hardware and software.

The survey is technology agnostic, making it flexible enough to assess a wide range of interface technologies, from IVRs and novel hardware platforms to the more traditional computer interfaces and Web sites. Second, the survey is relatively quick and easy to use by both study participants and administrators. Third, the survey provides a single score on a scale that is easily understood by the wide range of people (from project managers to computer programmers) who are typically involved in the development of products and services and who may have little or no experience in human factors and usability. Finally, the survey is non-proprietary, making it a cost effective tool as well. Bangor et al. (2008)[14] identified six major usages for SUS:

1. Providing a point estimate measure of usability and customer satisfaction
2. Comparing different tasks within the same interface
3. Comparing iterative versions of the same system
4. Comparing competing implementations of a system
5. Competitive assessment of comparable user interfaces
6. Comparing different interface technologies

The SUS scale consists of ten questions and offers a formula which transfers the subjective impressions of users into the objective data information for analysis(Figure 1).

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the website *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this website frequently.	☐	☐	☐	☐	☐
2.	I found this website unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought this website was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need assistance to be able to use this website.	☐	☐	☐	☐	☐
5.	I found the various functions in this website were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this website.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this website very quickly.	☐	☐	☐	☐	☐
8.	I found this website very cumbersome/awkward to use.	☐	☐	☐	☐	☐
9.	I felt very confident using this website.	☐	☐	☐	☐	☐
10.	I needed to learn a lot of things before I could get going with this website.	☐	☐	☐	☐	☐

Please provide any comments about this website:

Figure 1: Online version of SUS

The calculation procedure of the SUS score, involves first summing the score contributions from each item. Each item's score contribution range from 0 to 4. For items 1,3,5,7 and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Finally, the sum of the scores should be multiplied by 2.5 to obtain the overall value of SU.

3. CURRENT STUDY – THE EXPERIMENT

The 8.4" tablet has been chosen for testing, because the size of its display was estimated as to be suitable for optimal operation from the ergonomics point of view. This tablet works in the Android operating system. At the beginning of the experiment, 10 naive participants were asked to familiarize themselves with the Tablet PC interface. Naive participants have been chosen in order to examine the users' acceptance of the system, as well as, how fast they could learn to use the system they have never faced with before. After being engaged in solving several spatial ability tasks (Čičević, et al., 2013) [15] the participants were asked to respond to the System Usability Scale (SUS). Their immediate response to each item, rather than thinking about items for a long time was required. Respondent then indicates the degree of agreement or disagreement with the statement on a 5 point scale. SUS, developed by Brooke (1996)[12], had a great success among usability practitioners since it is a quick and easy to use measure for collecting users' usability evaluation of a system. It consists of ten-item scale giving a global assessment of Usability, operatively defined as the subjective perception of interaction with a system (Brooke, 1996)[12]. The selected statements actually cover a variety of aspects of system usability, such as the need for support, training, and complexity, and thus have a high level of face validity for measuring usability of a system. According to Jeff Sauro (2011)[16] SUS is not dependent on technology and it has been tested not only with hardware and websites but also on consumer software, mobile phones and even with yellow-pages. Sauro also states that SUS has become an industry standard. The SUS, reflect a strong need in the usability community for a tool that could quickly and easily collect a user's subjective rating of a product's usability.

In the aspect of system usability evaluation, the SUS is an efficient, time-conserving, and labor-saving way of subjective assessment. Before getting the actual SUS score, responses needed to be processed according to a defined method. The received raw user responses range from 1 (Strongly disagree) to 5 (Strongly agree). First these raw SUS item responses should be converted like this:

- For odd (positively worded) items (1, 3, 5, 7, 9), 1 should be subtracted from the user response.
- For even items (negatively worded) (2, 4, 6, 8, 10), subtract the user responses from 5.

This scales all the values to range from 0 to 4, with four being the most positive. After all the items are converted, responses from each user should be added up and multiplied with 2.5. As a result, SUS will produce a single number representing a composite measure of the overall usability of the studied system. The score is calculated by first summing the score contributions from each item. To get the overall SUS score, the sum of the item score contributions should be multiplied by 2.5. Thus, overall SUS scores range from 0 to 100 in 2.5-point increments. SUS questionnaire, as a whole, reflects participants' estimates of the overall usability of an interface, regardless of the type of interface. The principal value of the SUS is that it provides a single reference score for participants' view of a product's usability. As such, the individual statements that compose the SUS are secondary to the discussion of the instrument, in favor of the emergent score. In addition to the experimental, the pilot study was conducted with the users of various models of mobile phones (with and without touch screen as a main input device).

4. NUMERICAL RESULTS – TOPSIS VS SUS

Similarity of TOPSIS and SUS concepts regarding the meaning of absolutely positive as well as absolutely negative dimensions, leaded to the choice of this particular MADM method in the experiment. This could mean that there are characteristics of the statements that tend to result in generally positive or negative ratings. All characteristics were presented through 10-items questionnaire as standardized form for System characteristics evaluation, based on usability criteria defined by the ISO 9241-11[13].

It was noticed that these questions could be also set of criteria for the TOPSIS matrix (C_1 to C_{10}), while four types of devices (A_1 to A_4 , for Tablet PC, Smartphone device, and mobile phones with QWERTY and numerical keyboard, respectively) have been identified as alternatives. Each question has five alternatives for the response ranging from 1 (Strongly disagree) to 5 (Strongly agree). Subjects were in position to evaluate each of four types of devices.

Total mean scores on each question per one device were used for TOPSIS matrix input (x_{ij}). With the respect to the different meanings that reflect various aspects of user experience, equal weights were assigned to all criteria (questions). Questionnaire items are presented below:

- *C1*. I think that I would like to use this system frequently.
- *C2*. I found the system unnecessarily complex.
- *C3*. I thought the system was easy to use.
- *C4*. I think that I would need the support of a technical person to be able to use this system.
- *C5*. I found the various functions in this system were well integrated.
- *C6*. I thought there was too much inconsistency in this system.
- *C7*. I would imagine that most people would learn to use this system very quickly.
- *C8*. I found the system very cumbersome to use.
- *C9*. I felt very confident using the system.
- *C10*. I needed to learn a lot of things before I could get going with this system.

In this way, the input TOPSIS matrix appears to be as follows:

Table 2: Decision Matrix

	C1	***C2***	***C3***	***C4***	***C5***	***C6***	***C7***	***C8***	***C9***	***C10***
A1	3.6	2.4	3.3	2.3	3.8	2.3	4.2	2.4	3.8	2.1
A2	3.231	3.038	3.5	3.423	3.269	2.577	3.769	2.731	3.5	2.962
A3	3.152	3.091	3.303	3.303	3.606	2.636	3.515	2.848	3.545	2.939
A4	3.071	3.143	3.607	3.357	3.429	2.786	3.75	2.964	3.75	2.857
w	5	5	5	5	5	5	5	5	5	5

In step 2, the weighted normalized decision matrix has been created (Table 3.)

Table 3: Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	2.86	-3.09	2.365	-3.445	2.763	-2.776	2.837	-2.859	2.64	-3.134
A2	2.454	-2.331	2.571	-2.012	2.239	-2.491	2.455	-2.495	2.357	-2.203
A3	2.367	-2.269	2.368	-2.165	2.571	-2.43	2.23	-2.365	2.4	-2.227
A4	2.279	-2.207	2.681	-2.096	2.396	-2.277	2.438	-2.238	2.592	-2.316
	max	min	max	min	max	min	max	min	max	min

In step 3, the positive-ideal, as well as negative-ideal solution has been determined, as shown in Table 4.

Table 4: The positive-ideal solution (A^+) and the negative-ideal solution (A^-)

A^+	2.86035	-3.0899	2.68102	-3.4451	2.76274	-2.7759	2.83744	-2.85852	2.63954	-3.13421
A^-	2.27885	-2.2071	2.36518	-2.0121	2.23903	-2.2765	2.23018	-2.23813	2.35674	-2.20309

In step 4, the ideal separation, as well as negative-ideal separation has been determined, as shown in Table 5.

Table 5: The ideal separation (S^+) and the negative-ideal separation (S^-)

S_1^+	0.315847	S_1^-	2.322775
S_2^+	2.09447	S_2^-	0.501168
S_3^+	2.07414	S_3^-	0.43324
S_4^+	2.12993	S_4^-	0.493144

Finally, in step 5 the relative closeness (C_j) to the ideal solution is calculated and the set of alternatives is ranked according to the decreasing order of C_j, in step 6, which is presented in Table 6.

Table 6: The relative closeness (C_j) to the ideal solution and the rankings of the alternatives

C_j	Rank
0.880299	**A1**
0.193081	**A2**
0.172786	**A4**
0.188002	**A3**

So, according to the results of the TOPSIS method the final rank of alternatives (ratings of the device usability) shows that from the perspective of the usability, Tablet PC is the most preferred device, followed by smartphone, mobile phones with numerical keyboard, and mobile phones with QWERTY keyboard, respectively.

Obviously, the average SUS score has been the highest for the Tablet PC. Mobile devices showed significantly lower overall SUS scores values than one in Tablet PC experiment, but it could be noticed that they are almost equal comparing the cases with and without touch screen (Figure 2).

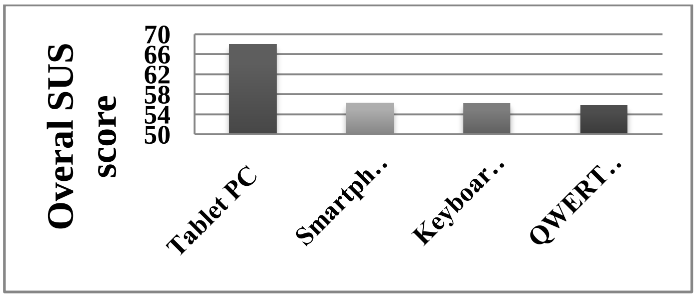

Figure 2: Overall SUS scores

The most important finding is the ranking order of overall SUS scores. These values reflect the same ranking order of devices as is the one gathered by TOPSIS method (Table 7).

Table 7: Ranks of various types of mobile device according to the SUS and TOPSIS

Device type	**Overall SUS Score**	**TOPSIS C_j value rank**	**Ranking order**
Tablet PC	68	0.880299	1
Smartphone	56.34615	0.193081	2
Keyboard mobile	56.25	0.172786	3
QWERTY mobile	55.75758	0.188002	4

The similarity of the results obtained by employed approaches to the problem, could be also noticed, and could be discussed in the following section.

CONCLUSIONS

In our analysis of the advantages and challenges of Tablet PC, we tackle the problem of its overall usability including comparison to similar kinds of mobile devices.
One of the most frequently used and promising approaches that has been proposed for decision making and selection is the Multiple Attribute Decision Making (MADM).
Among the various methods which belong to MADM, the TOPSIS method is the logical choice for usage in combination with SUS scale, in order to investigate the problem of appropriate device selection for the purposes as described in introduction. Despite the fact that the two above mentioned methods do not belong to the same scientific discipline, the motivation for their application in this research is based on some of their similarities. Although the TOPSIS method is not a common tool to be applied for usability testing, it is interesting that it gives the same ranking results as the SUS scale. Even more, the ratios between resulting ranking values are the same as those in SUS scores (r = 0.99861).

Hence, one of the conclusions is that the TOPSIS method could be utilized in the field of usability measurement. One of the TOPSIS method advantages is its ability to identify the best alternative quickly (Paxkan & Wu, 1997) [17] and precisely, which is also one of the most important features of SUS scale.

Future analysis could be oriented to the investigation of possible usage of other MADM methods in combination with different scales for usability testing.

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