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Aesthetic Mobile Learning Interfaces Ranking based on TOPSIS Approach

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Abstract. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) approach is applied to evaluate the aesthetic of mobile learning interfaces. TOPSIS approach is a valuable distance-based technique for ranking and selecting several alternatives. Nine design principles, balance, proportion, simplicity, and others, are applied in mobile learning interface design. There are 15 mobile learning interfaces divided into three types of interfaces, namely Homepage, Introduction page, and Learning page. This study found that Interface 1 (Homepage), Interface 6 (Introduction Page), and Interface 15 (Learning Page) are the interfaces that are considered aesthetic for mobile learning interfaces.
Keywords: Mobile learning interface, aesthetic, principle design, TOPSIS, information management, library management.

1 Introduction

Aesthetics is a significant factor that can influence people's interests. One of the factors driving academicians to integrate technology into mobile interface design elements is the rapid growth of technology. As a result of the importance of aesthetics in mobile interface design, this study aims to identify aesthetic interfaces for mobile learning applications for primary education. This study considers mobile learning interfaces such as homepages, introduction pages, and learning pages designed using the selected design principles. The current study has considered the design principles of balance, proportion, simplicity, alignment, movement, hierarchy, consistency, contrast, and proximity.

On the other hand, researchers used various study techniques to design, select, and evaluate mobile interfaces. Chen et al. (2009) used TOPSIS and Hierarchical Clustering Analysis (HCA) techniques to evaluate the various menus and categories used in the menu-icon interface design of a personal digital assistant. Kumar et al. (2019) then applied Multi-Criteria Decision-Making (MCDM) to evaluate the quality of mobile e-commerce. The best network interfaces were selected by using TOPSIS and Analytic Hierarchy Process (AHP) by Mohammed et al. (2018). Besides that, Tin-Chih & Chi-Wei Lin (2022) applied the Fuzzy technique to choose the right choice from a group of technology applications supporting mobile health care. Most studies used various techniques for mobile interfaces, such as HCA, MCDM, AHP, and others. Not many studies adopted the TOPSIS technique to evaluate or rank the aesthetic of mobile interfaces. As a result, the TOPSIS approach will be used to rank the aesthetic mobile interfaces in this study.

TOPSIS is an MCDM approach that ranks various accessible alternatives/options. TOPSIS categorizes the possibilities as Positive Ideal Solution (PIS) or Negative Ideal Solution (NIS). The best option is the farthest from the PIS and the closest to the NIS. Terol et al. (2014) pointed out that the PIS has the greatest functioning values, whereas the NIS has a collection of the lowest working values. At the same time, PIS consists of the highest yield criterion while reducing the cost criterion. In contrast, NIS is the opposite of PIS, which consists of the lowest criterion results while maximizing the cost criterion (Benitez et al., 2007).

This research is significant because it can contribute to the interface design domain, particularly in mobile application interfaces, and play a role in the learning domain, particularly at the primary school level. This research also will serve as the basis for future studies on designing aesthetic mobile interfaces based on design principles. According to Zhang (2007), design principles are more fundamental and broadly applicable than design guidelines. Additionally, design principles assist in the facilitation of a structured design process.

Furthermore, the TOPSIS technique will be used in this study to rank the aesthetic of mobile interfaces. This is because the TOPSIS technique compares a set of alternatives to determine the best choice based on a predefined principle design or criteria (R. Singh & Ram, 2020). Thus, instead of the commonly used techniques such as HCA, MCDM, AHP, and others, this study may provide an alternative technique or approach, TOPSIS, for ranking or evaluating interfaces.

This paper is organised as follows. Firstly, a review of research background relating to the aesthetic of mobile interface design is provided. The TOPSIS methodology is then described, followed by the results and discussion. Finally, this paper ended with a conclusion.

2 Literature Review

This part of the literature review describes the background of this study, such as the aesthetics, mobile learning, and design of mobile learning interfaces.

2.1 Aesthetic

Aesthetics, according to Baumgarten, is concerned with sensory information aimed at beauty (Suzen, 2020). Since its beginnings, aesthetics has been the subject of debates about subjectivity and objectivity. Until recently, the academy considered aesthetics a subjective term; however, several studies have found objectivity in beauty. Besides that, aesthetics in human-computer communication can also be divided into two types: classic and artistic aesthetics (Ahmed et al., 2009). Classical aesthetics is concerned with a straightforward design, whereas expressive aesthetics is concerned with many more creative designs. Aesthetic appeal, particularly concerning interface icons, has been defined as moderate aesthetic, referring to the ability to engage users (McDougall et al., 2016). Information structure is related to recognising aesthetics and usability in system design (Cyr, 2009). User interfaces interact with graphical elements such as menus, icons, and windows which provide intuitiveness and immediate visual feedback (Jylhä, 2021). The aesthetics interface design is an important component of excellent user knowledge and opinion (Ngo et al., 2001 & Salimun et al., 2010;).

2.2 Mobile Learning

Mobile learning has become a landmark in education technology. Mobile learning technologies, according to Siozos et al. (2009), have influenced several aspects of the education field and provide instructors with a method of transmitting knowledge and inspiring students to use it in many learning activities. According to Donaldson (2010), due to the rapid evolution of mobile technology in educational activities, students who use smartphones with internet access have evolved conversation technique, work in grouping, entry to history learning, and access to online information.

2.3 Mobile learning interfaces design

Ping Zhang et al. (2006) indicate that design principles are "high-level, generally, context-free design goals based on human-computer interaction theories." Design principles are more structural and broadly relevant than design guidelines. Design principles, which are more abstract than design rules, help to organize the design process.

While according to Ngo (2001), the seven commonly used design principles for interfaces are balance, equilibrium, simplicity, unity, density, proportion, and economy study. While by Seraj & Wong (2012), there are six (6) factors for design principles which include consistency, minimal action, flexibility, learning capability, user guidance, and minimal memory load. Following that, Kalimullah & Sushmitha (2017) proposed Unitarian Universalism principles, mobile design guidelines, inclusive design guidelines, and mobile health guidelines as user interface design elements for mobile design. Lazard et al. (2016) stated that the web has four (4) design principles: simplicity, diversity, colourfulness, and craftsmanship.

This study applied nine (9) design principles balance, proportion, simplicity, alignment, movement, hierarchy, consistency, contrast, and proximity to design mobile learning interfaces. Each interface applied three (3) different design principles. Tables 1, 2, and 3 depict three (3) design principles applied for the Homepage, Introduction page, and Learning page, respectively. Altogether there are 15 mobile interfaces.

Table 1: Combination of design principles for Homepage

Interfaces	Design principle
1	Balance, Proportion, Simplicity
2	Alignment, Movement, Hierarchy
3	Balance, Consistency, Simplicity
4	Balance, Proportion, Alignment
5	Balance, Consistency, Contrast

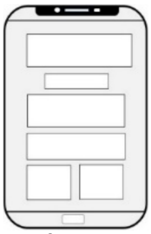
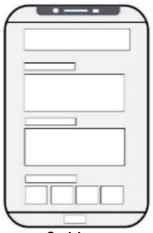
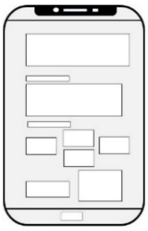
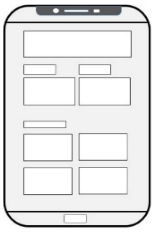
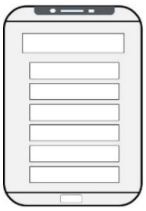
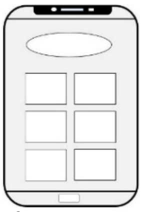
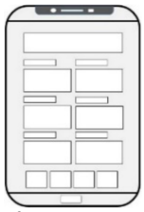
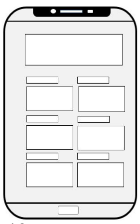
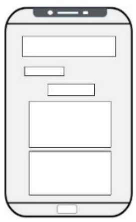
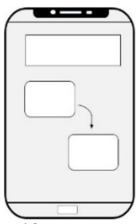
Table 2: Combination of design principles for Introduction page

Interfaces	Design principle
6	Balance, Proportion, Simplicity
7	Balance, Contrast, Simplicity
8	Balance, Proportion, Simplicity
9	Balance, Alignment, Proximity
10	Balance, Proportion, Contrast

Table 3: Combination of design principles for Learning page

Interfaces	Design principle
11	Proportion, Contrast, Consistency
12	Contrast, Proximity, Proportion
13	Balance, Consistency, Simplicity
14	Balance, Alignment, Proximity
15	Balance, Proximity, Contrast

On the other hand, Figures 1 to 15 shows the mobile learning interface design that applied three (3) combinations of design principles for homepages, introduction pages, and learning pages.

 Figure 1: Homepage Mobile interface 1	 Figure 2: Homepage Mobile interface 2	 Figure 3: Homepage Mobile interface 3
 Figure 4: Homepage Mobile interface 4	 Figure 5: Homepage Mobile interface 5	 Figure 6: Introduction page Mobile interface 6
 Figure 7: Introduction page Mobile interface 7	 Figure 8: Introduction page Mobile interface 8	 Figure 9: Introduction page Mobile interface 9
 Figure 10: Introduction page Mobile interface 10	 Figure 11: Learning page Mobile interface 11	 Figure 12: Learning page Mobile interface 12

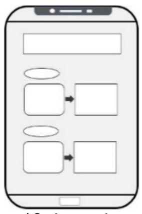


Figure 13: Learning page
Mobile interface 13

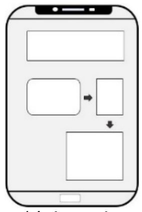


Figure 14: Learning page
Mobile interface 14

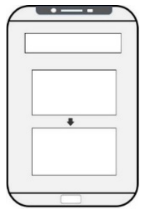


Figure 15: Learning page
Mobile interface 15

3 Methodology

This study adopted the TOPSIS approach to rank the aesthetic interfaces. TOPSIS, presented by Lolli et al. (2015), is a conceptual and implementation ranking system. The PIS boosts qualities while lowering value characteristics, although the NIS lowers benefit qualities while rising value characteristics. Hwang and Yoon also created TOPSIS (1981).

Then, the TOPSIS presented by Mardani et al. (2015) also is a conceptual and implementation ranking system. The traditional TOPSIS technique looks for benchmarks that are close to the PIS while far from the NIS. PIS increasing benefits while lowering value, while NIS decrease benefits while increasing values.

Torrance (1978) used the interview method to deal with the problem in MCDM, which creates a non-linear additive linear utility function from the beginning of the TOPSIS. There are numerous approaches, including the best and worst method (Rezaei, 2015), the analytic hierarchy process (Condon et al., 2003), the characteristic object's method (Salabun, 2015), rough sets (Liang et al., 2015), and the fuzzy sets method (Mardani et al., 2015). The authors of Zavadskas et al. (2018) intend to conduct a precise analysis of the operation and methodologies of MCDM techniques or approaches, which will provide us with valuable guidance in fully understanding the MCDM.

The TOPSIS technique assumes that each benchmark has a lowering or increasing value (Pavi and Novoselac, 2013). As a result, identifying the PIS and NIS is straightforward. The Euclidean technique was recommended to assess the corresponding closeness of the chosen alternatives to the ideal solution. The basic idea behind this technique is that the options chosen should be those nearest to the PIS and distant to the NIS (Balioti et al., 2018). TOPSIS technique for selecting the ideal solution for aesthetic interfaces is explained in the following sub-sections.

3.1 Step 1. Generate the decision matrix and establish the weight of the criteria.

The first way is to decide the weight of the criteria. The formula for adding all the weight criteria is shown in Equation 3.1. Object criteria can be aid functions (more is superior) or amount functions (less is superior).

Let $X = (x_{ij})$ be a decision matrix, and
W = $[w_1, w_2, \ldots, w_3]$ a weight vector,
where $(x_{ij}) \in \Re$, $w_j \in \Re$ and $w_1 + w_2 + \ldots, w_n = 1$. (1)

Decision Matrix Value = $\sqrt{((w_1)^2 + (w_2)^2 + (w_3)^2 + (w_4)^2 + (w_5)^2}$
= Dmv (2)

3.2 Step 2. Measures the weighted normalized decision matrix.

This way covers different feature dimensions into non-dimensional attributes, enable for cross-criteria distinction. The amount in the evaluation matrix X should be normalized because different criteria are commonly measured in different units. To normalize values, a few standardized formulas can be used. One of the common approaches to determining the normalized value is as follows:

Standardize Dmv = w_1 / Dmv (3)

Construct weight = w_1 X Standardize Dmv (4)

3.3 Step 3. Select the ideal solution.

Following is the calculation of the weighted formal value vij:

$v_{ij} = w_j n_{ij}$ for i = 1, …, m; j = 1, …, n. (5)

where w_j is the weight of the j-th benchmark, $\sum_{j=1}^{n} w\, j = 1$.

3.4 Step 4. Determine the PIS and NIS.

The positive ideal solution maximizes benefit criteria while decreasing value criteria, whereas the negative ideal solution decreases benefit criteria while increasing value criteria.
Positive ideal solution S^+ has the form:
$A^+ = (v_1^+, v_2^+, \ldots v_n^+) = ((\max_i v_{ij} \mid j \in I), (\min_i v_{ij} \mid j \in I))$

Negative ideal solution S^- has the form:

$A^- = (v_1^-, v_2^- ,\ldots v_n^-) = ((\min_i v_{ij} \mid j \in I), (\max_i v_{ij} \mid j \in I))$ (6)

Where I is related with benefit criteria and J with the cost criteria, i = 1, …, m; j = 1, …, n.

3.5 Step 5. Compute the distances between the ideal solutions, both positive and negative.

The TOPSIS method can be applied to two different distance measurements which are:

The distance between each benchmark and the positive ideal solution is given as

$$\boldsymbol{d_i^+} = (\textstyle\sum_{j=1}^{n}(\boldsymbol{v_{ij}} - \boldsymbol{v_j^+})^{\boldsymbol{p}})^{\boldsymbol{1/p}} \quad , i = 1, 2, \ldots , m. \tag{7}$$

The distance between each benchmark from the negative ideal solution is given as

$$\boldsymbol{d_i^-} = (\textstyle\sum_{j=1}^{n}(\boldsymbol{v_{ij}} - \boldsymbol{v_j^-})^{\boldsymbol{p}})^{\boldsymbol{1/p}} \quad , i = 1, 2, \ldots , m. \tag{8}$$

Where p ≥ 1. For p =2, it has the most used traditional n-dimensional Euclidean metric.

$$\boldsymbol{d_i^+} = \sqrt{\textstyle\sum_{j=1}^{n}(\boldsymbol{v_{ij}} - \boldsymbol{v_j^+})^{\boldsymbol{2}}} \;, I = 1,2, \ldots, m, \tag{9}$$

$$d_i^- = \sqrt{\textstyle\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \;, I = 1,2, \ldots, m, \tag{10}$$

3.6 Step 6. Determine the relative closeness to the positive ideal solution.

The relation of the i-th benchmark Aj to A+ is defined as

$$\boldsymbol{R_i} = \frac{\boldsymbol{d_i^-}}{\boldsymbol{d_i^-} + \boldsymbol{d_i^+}} \tag{11}$$

where $0 \leq R_j \leq 1$, $i = 1,2, \ldots, m$

3.7 Step 7. Rank the preference order or chose the benchmark closest to 1.

The descending order of the R-value can rank a set of the benchmark.

4 Result and discussion

According to Shyur et al. (2015), corresponding closeness to an ideal solution equal to one (1) is considered the best result by the TOPSIS approach. Thus, it is found that Interface 1 (Homepage), Interface 6 (Introduction Page), and Interface 15 (Learning Page) achieve the value 1. Therefore, these three (3) interfaces are the ideal solution for the mobile learning interface, as shown in Table 4. An ideal solution interface is considered an aesthetic interface.

Table 4: Determine relative closeness to an ideal solution

Type of interfaces	Interface	Relative closeness to ideal solution values
Homepage	1	Si* + Si' :0 + 0.79 = 0.79 Si'/(Si* + Si') : 0.79 / 0.79 = 1
	2	Si* + Si' : 0.06 + 0.42 = 0.48 Si' / Si* + Si'): 0.42 / 0.48 = 0.88
	3	Si* + Si' : 0.32 + 0.10 = 0.42 Si' / (Si*+ Si'): 0.10 / 0.42 = 0.24
	4	Si* + Si' : 0.79 + 0 = 0.79 Si' / (Si*+ Si'): 0 / 0.79 = 0
	5	Si* + Si' : 0.32 + 0.12 = 0.44 Si' / (Si*+ Si'): 0.12 / 0.44 = 0.27
Introduction page	6	Si* + Si' : 0 + 0.58 = 0.58 Si' / (Si*+ Si'): 0.58 / 0.58 = 1
	7	Si* + Si' : 0.04 + 0.31 = 0.35 Si' / (Si*+ Si'): 0.31 / 0.35 = 0.86
	8	Si* + Si' : 0.14 + 0.2 = 0.34 Si' / (Si*+ Si'): 0.20 / 0.34 = 0.59
	9	Si* + Si' : 0.2 + 0.26 = 0.46 Si' / (Si*+ Si'): 0.26 / 0.46 = 0.57
	10	Si* + Si' : 0.40 + 0 = 0.40 Si' / (Si*+ Si') : 0 / 0.40 = 0

Type of interfaces	Interface	Relative closeness to ideal solution values
Learning page	11	Si* + Si' : 2.37 + 0 = 2.37 Si' / (Si*+ Si') : 0 / 2.37 = 0
	12	Si* + Si' : 1.32 + 0.15 = 1.47 Si' / (Si*+ Si') : 0.15 / 1.47 = 0.10
	13	Si* + Si' : 1.93 + 0.02 = 1.95 Si' / (Si*+ Si') : 0.02 / 1.95 = 0.01
	14	Si* + Si' : 1.49 + 0.07 = 1.56 Si' / (Si*+ Si') : 0.07 / 1.56 = 0.04
	15	Si* + Si' : 0 + 2.37 = 2.37 Si' / (Si*+ Si') : 2.37 / 2.37 = 1

Table 5: Aesthetic interfaces and design principles

Interface	Page	Design principles
1	Homepage	Balance, proportion, and simplicity
6	Introduction page	Balance, proportion, and simplicity
15	Learning page	Balance, proximity, and contrast

As presented in Table 5, there are three (3) mobile interfaces designed for the Homepage, Introduction page, and Learning page that are considered ideal solutions or aesthetic interfaces in which, Interface 1 is for the Homepage, Interface 6 is for the Introduction, and Interface 15 is for Learning page. This finding suggests that the interfaces with balance, proportion, proximity, simplicity and contrast were the most aesthetic design principles for mobile learning interfaces.

According to Table 5, the most important design principle for aesthetic mobile interfaces is balance. Three (3) out of three (3) of the interfaces consist of balance design principles: Interface 1, Interface 6, and Interface 15. Then, followed by the proportion applied on Interface 1 and Interface 6 (2 out 3 interfaces). Next, simplicity is applied to Interface 1 and Interface 6 (2 out 3 interfaces). Lastly, proximity and contrast are applied on Interfaces 15 (1 out 3 interfaces).

Thus, it could be argued that balance design principles are the most important in designing aesthetic interfaces for mobile learning interfaces because when there is balance in a design, it is more appealing. Besides, balance in mobile application design positively relates to mobile application interface design (Bhandari et al., 2017).

5 Contribution research

The first contribution is that nine (9) design principles can be used to create 15 mobile learning interfaces. This could be used as guidelines when designing mobile application interfaces. Secondly, balance, simplicity, contrast, proximity, and proportion principles were the most preferred aesthetic design principles for mobile learning interfaces in the Malaysian industry. As a result, it implies that design principles such as balance, proportion, and contrast contribute to the non-aesthetic interfaces for mobile learning interfaces.

This study investigates the design principles of aesthetic and non-aesthetic interfaces in mobile applications that can be used by user interface designers and others involved in interface design when developing mobile interface applications in the primary education domain. Ranking user interfaces with TOPSIS is recommended for future research in other areas such as business, management, and other user interface design because TOPSIS is appropriate for ranking the best ideal solution (Mohammed et al., 2018).

6 Conclusion

In summary, this study aims to identify the aesthetic of mobile learning interfaces using the TOPSIS approach. The mobile learning interfaces were produced from nine (9) design principles: balance, simplicity, alignment, proximity, movement, consistency, hierarchy, contrast, and proportion. According to the findings of this study, design principles of balance, simplicity, contrast, proximity, and proportion could contribute to the aesthetic interfaces for mobile learning applications.

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