An Initial Study of Measuring Aesthetic Web Interfaces Using Fuzzy Analytic Hierarchy Process (FAHP) Approach

Zuriana Abu Bakar, Fatin Sarah Salim, Noor Maizura Mohamad Noor, Rosmayati Mohemad

Faculty of Ocean Engineering Technology and Informatics, Universiti Malaysia Terengganu, Terengganu, Malaysia

ABSTRACT

Aesthetic denotes the high loading of general feeling, beauty, and meaningfulness. The aesthetic of the web interface is vital since it could influence the users' initial impression, attention, satisfaction, subjective experiences and successful communications. However, the aesthetics of the web interface is very subjective because different individuals might have their own perspective. Hence, the judgement whether the web interface is aesthetically appealing or not, is not absolutely accurate and reliable based on the subjective evaluation. As a result, there is uncertainty in the decision of aesthetically web interfaces. Thus, in order to response to this issue, this research aims to construct a model that can objectively measure the aesthetic of the web interface. The present study intends to focus on the web-based learning interface because the aesthetic of the interface could attract students to the content of the learning modules and drive students to further explore the learning materials. The objectives of this research are to design web-based learning interfaces based on the aesthetic design principles selected, to develop a model for measuring aesthetic web-based learning interfaces based on Fuzzy Analytic Hierarchy (FAHP) approach and, to evaluate the proposed model in a web-based learning domain. In order to construct an aesthetic measuring model for web interfaces, this study will employ FAHP approach. The expected findings of the current research are the ranking of aesthetic criteria that used to create the web interfaces, and subsequently, can give a consistent criterion that could contribute to the aesthetic of web interfaces, this research is significant because it is able to produce a model that can assist in determining the aesthetic web-based learning interfaces. Taken together, it is also could contribute to the body of knowledge in the interface design and decision support system fields.

Keywords: *Fuzzy Analytic Hierarchy Process, Human Computer Interaction, Web Interface.*

I. INTRODUCTION

Aesthetic refers to the high loading on the whole of impression, beauty and meaningfulness. The aesthetic of the web interface is crucial since it effect the users' initial impression, attention, satisfaction, subjective experiences and effective communications. However, the aesthetics of the web interface is very subjective because different individuals might have their own perspective. Hence, the judgement whether the web interface is aesthetically appealing or not is not absolutely accurate and reliable based on the subjective evaluation. As a result, there is uncertainty in the decision of aesthetically web interfaces. Thus, in order to response to this issue, this research aims to construct a model that can objectively measure the aesthetic of the web interface. The present study intends to focus on the web based learning interface because the aesthetic of the interface could encourage students to the content of the learning modules and inspire students to further explore the learning materials. The objectives of this research are to design web based learning interface based on the selected aesthetic design principles, to develop a model for measuring aesthetic web based learning interface based on the FAHP approach and to evaluate the proposed model in web based learning domain. In order to construct an aesthetic measuring model for web interfaces, this study will be employing FAHP approach. The expected findings of the current research are the ranking of aesthetic criteria that used to create the web interfaces, and subsequently can give a consistent criterion that could contribute to the aesthetic of web interfaces. This research is significant because it is able to produce a model that can assist in determining the aesthetic of web based learning interfaces. Taken together, it could also contribute to the body of knowledge in the interface design and decision support system (DSS) fields.

The remainder of the paper are discussed in the following sections. Section II discusses the problem statement of this paper, whereas Section III discusses about the literature used in this research. Afterwards, the methodology adopted the paper is explained in Section

IV which is the FAHP approach. Finally, the conclusion of this paper in presented in Section V.

II. PROBLEM STATEMENT

In the millennium age, web based platform becomes an essential medium to transfer information, knowledge and doing business as well. In human system interaction, the users need to interact with the software interface in order to perform the business activities. Therefore, the user interface of a web based application plays a crucial role to make sure that the interaction process went smoothly. This is because the interface of an application is the first thing the user see when browsing the web based application. A study by [1] discovered that it took only 50 milliseconds for people to determine whether they like or dislike the web page they were presented with, and that this decision was attributable to the page's visual appeal. This study reveals how quickly the beauty of web page attracts users to use the application.

However, the aesthetics of the interface is very subjective because different people might have their own different views.When individuals are judging something, even using the same words they may significantly differ since each of them has different subjective perception or personality [2]. Similarly, in designing web interfaces, the web designers usually based on their subjective perception. Undoubtedly, there is design guidelines for facilitating the web designers but there is still no standard design rules or models that web designers may follow in order to produce aesthetic web interfaces. Subsequently, it is very challenging to measure the aesthetics of interfaces based on the subjective evaluation. In addition, Fuzzy Analytic Hierarchy Process (FAHP) approach have been applied mostly in evaluating teaching performance [3] and others field but the use of this approach is still limited in evaluating the aesthetic of interfaces. Therefore, there is a need to develop an objective evaluation in measuring the aesthetic of the interfaces using FAHP approach in order to produce consistent aesthetic web interfaces.

The current study will focus on the web based learning interfaces. This is because the user interface is the point of interaction between student and application in the web based learning environment. Generally, a well-designed interface provides students with good experience and effective learning [4]. In addition, a good interface could elicits a variety of emotions [5] and it is a motivating factor for engaging learners in an online learning domain [6]. Overall, even though the greatest advantage of an interface is its ability to evoke student's emotions and influence student's engagement and cognition, there is still no standard design guidelines for facilitation the web based learning process using interface design components. In addition, despite the significance of an instructional interface design, very few instructional designers are knowledgeable with the specific functions of an instructional interface, the designing process, or the criteria for good design [7].

III. LITERATURE REVIEWS

A number of research has been carry out to measure the visual appeal or aesthetic of web interfaces or pages. With regard to objective measurement, a number of studies have assessed the visual appeal of interfaces by calculating the values of the design principles such as symmetry, balance and unity - just to name a few [8]–[13]. Ngo *et al*., (2000) identified fourteen design principles that are crucial for getting user's attention to use the created computer systems. These design principles are balance, density, symmetry, sequence, cohesion, unity, proportion, simplicity, equilibrium, homogeneity, economy, regularity, rhythm, as well as order and complexity.

Ngo *et al*., (2000) later extended their research to identify whether or not the user perception is congruent with the fourteen design principles values (derived from their first study) measured by the system. They used the mathematical formulae to calculate the values of design principle. There are seven (7) participants in this study that are from multi-media company that are working as Graphical User Interface (GUI) designers. They could all be classified as professionals, with one (1) to six (6) years of experience in GUI design. The result of the experiment indicated a highly significant relationship between these two (2) data which shows that the model is to some extent is related to the viewer's perceptions of aesthetics. Other studies such as the works by Zain, Tey, & Goh (2007) [14] and Zain *et al*., (2008) [15] applied a part of the fourteen aesthetic design principles introduced by Ngo *et al*., (2000) [9]. They found that the aesthetic values measured for the interfaces using this model were congruent with the aesthetic ratings of user perceptions. Table I summarize the studies of aesthetic measurement based on the design principles and element values.

Table I: Literature in the field of aesthetic judgementbased on design elements/principles

Author(s)/Year	Elements
Zain, Tey, Goh (2008) [13]	Measured six (6) design elements drawn from Ngo et. al. (2000) - balance, equilibrium, symmetry, sequence, rhythm, order, complexity
Jiang, Wang, Tan, Yu (2016) [16]	Measured five (5) design elements - unity, complexity, intensity, novelty, interactivity

Lazard *et al.*, (2016) [17]	Measured four (4) design principles - simplicity, diversity, colorfulness, craftsmanship
Reinecke, Bernstein (2011) [18]	Measured ten (10) design principles - information density, navigation, accessibility of functions, guidance, structure, colourfulness, saturation, image-to-text ratio, support, help-text
Moustakis, Litos, Daviligas, Tsironis [19](2004) [19]	Measured five (5) design principles - content, navigation, design and structure, appearance and multimedia, uniqueness
Reinecke *et al.*, (2013) [20]	Measured two (2) design principles - colorfulness and visual complexity

As can be seen from Table I, there are many design principles (criteria) that contributing to the aesthetic of interfaces. However, the previous studies did not determine the criteria is the most or least important in constructing web interfaces, that have aesthetic value. In addition, the previous studies were just adding or combining the criteria in measuring aesthetic of web interfaces. There is no firm combination of criteria that could be a model to be obeyed to construct a pleasant web interfaces. On the other hand, none of the previous studies as stated in Table I applied DSS method in measuring the aesthetic interfaces.

Table II: Literature for measuring websites using DSS/model

Authors	**Elements Measured**	**Techniques**
Ecer (2013) [21]	Websites quality using a hybrid model that considered three (3) main criteria which are information, service and system quality	Analytic Hierarchy Process (AHP and Grey Comple Proportional Assessment (COPRAS-G)
Mu, Wormer, Barkon, Foizey, Vehec (2009) [22]	Making Selection of e-portfolio using the criteria of functionality that is the ease of use and aesthetic.	AHP
Dominic, Jati, Kannabiran (2010) [23]	Quality of Asian e-government website focusing in four (4) criteria which are service, user, content, usability	AHP
Vatansever, Akgul (2017) [24]	Airlines companies websites performance using criteria such as traffic, page rank, design optimization, load time, response time, mark up, broken link.	Entropy Weight Method, Grey Relational Analysis & AHP
Yee *et al.*, (2018) [25]	Performance of hotel booking website through load time, page size, number of items, broken links, response time, page rank, traffic, design optimization and markup validation	AHP
Garg, Jain (2017) [26]	Evaluating e-learning website by two (2) main criteria that is quality factors and e-learning specific factors. The quality factors are the function, ability to be maintain, ability to be use in different devices, reliability, usability and efficiency. Whereas the e-learning factors are ease of learning community, personalization, system content and general factors.	FAHP, COPRAS, VisekriterijumskoKompromisnoRangiranje (Vikor) & Weighted Distance Based Approximation (WDBA)
Harshan, Chen, Shi (2017) [27]	Library website usability measured by using accessibility, content, efficiency, learnability, navigation, satisfaction and usefulness	AHP
Masudin (2016) [28]	Usability of B2C website by evaluating nineteen (19) usability factors which are security &privacy, authorization, feedback,	FAHP & Hierarchical Fuzzy TOPSIS

	easy-to-follow shop and checkout links, content arrangement, loading instance, constructive error message, clear link, description, instruction & help, robust search, easy navigation, clear layout, the use of jargon, constant term & design, orderly page, appropriate navigation information, interesting to explore, visually appealing and personalize	
Anggraining sih, Umam, Setiadi (2017) [29]	E-learning success factor at Sebelas Maret University by two (2) factors that is through lecturer perspective and what effected students. Factors according to lecture perspective are the financial policy, regulatory policy, course quality, relevant content and technical support. Whereas, factors effecting according to student are course importance, related content, completeness of content, view toward student, flexibility in taking course.	FAHP

Table II above illustrates the growing body of literature for measuring website using DSS technique/model. The table shows that, so far, most of the previous studies have used DSS technique/model to measure the website based on the quality, usability and the accomplishment of the interfaces. Those factors are regarded as important as it is considered as the deciding factor in determining the success of a website. However, it seems that only a little studies measure the web interfaces based on the aesthetic criteria using DSS technique/model. Thus, in order to fill in the gap, the purpose of the present study is to evaluate the aesthetic of the web interface objectively which is based on FAHP approach in order to develop a model that could be used as a rule in developing aesthetic web interfaces.

IV. METHODOLOGY

The present study will adopt FAHP approach in facilitating decision making for measuring the aesthetic web based learning interface. Fundamentally FAHP approach is originated from Multi Criteria Decision Making (MCDM) approach. MCDM provides an outline for inter-websites disparity involving the evaluation of multi criteria[30]. MCDM is divided into two (2) approaches which are Multi Attribute Decision Making (MADM) and Multi Objective Decision Making (MODM). Subsequently, FAHP approach is considered under MADM, in which the overall MCDM classification can be seen in Fig. 1.

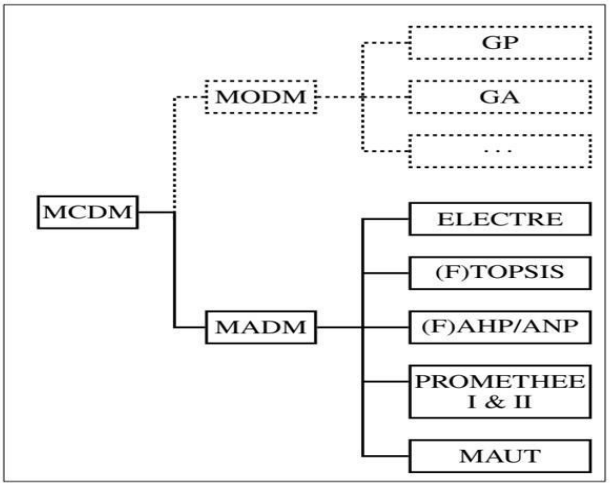

Figure 1: Classification of MCDM used in this study [31]

As illustrated in Fig. 1, Analytic hierarchy process (AHP) is one of the most commonly applied MADM [31]. Thomas L.Saaty first introduced AHP in the 1970s and since it had been broadly accepted by researchers and practitioners [31]. AHP aids decision makers in structuring complex problem to a form of a simple hierarchy and to assess a large number of quantitative and qualitative factors in an organized manner under multiple contradicting criteria [32]. Furthermore, AHP is flexible, whereas it could be incorporated with the other techniques like Linear Programming, Quality Function Deployment, Fuzzy Logic and so forth [33].

On the other hand, the father of the fuzzy set theory which is Zadeh (1965), stated that fuzzy logic or fuzzy set theory is a method of dealing with vague concepts and provides a means for expressing uncertainty in order to handle the vagueness involved in the real situation [34]. Due to the fuzziness and vagueness of human decision making, fuzzy is often applied to tackle MCDM

problems. As a result, AHP which breaks down a complex problem into simple hierarchical decision making processes can be integrated with fuzzy logic to suggest the relative strength of the factors in the corresponding criteria, thereby enabling the construction of a fuzzy judgment matrix to facilitate decision making [32]. The combination of Fuzzy Logic and AHP is commonly known as Fuzzy AHP or FAHP.

A FAHP algorithm for evaluating aesthetic web based learning interfaces are explained [32] by first identifying the problems to be solve and then a hierarchical structure will be constructed. Then fuzzy judgment matrix is established and weight vector define. After that, weight numbers will be calculated and fuzzy scores will be formed so that it can be rank to determine the optimum alternative

This study aims to focus on interfaces for web based learning for evaluation purpose. This is because the visual aesthetic in the appearance of the system is important since it can enhanced the process of learning by giving on how the learning material is presented and how interaction between the students and the material is done [34]. Furthermore, the appeal and visual organization (structure) of the interface can draw the students to the content of the learning modules and lead students to further explore the learning materials. There are many approach that can be applied to design web interfaces, but this study will apply most commonly used approach of design principles in web design which are contrast, balance, alignment, simplicity and consistency.

The principles of design are the rules of designing anything [35]. The rules acts as the fundamental idea that provide guidance to the design practice and determine the influence of arrangement of design objects within a composition such as shape, line and space [36]. They have been applied in various mediums including canvas, film, paper, and on the web [37], [38]. For a web interface, a well-built design principle can formulate an effective layout which reinforces a site's content organization by letting user knows what content items are related, consequently making navigation easier.

This research consists of five (5) phases which are feasibility study, design of web interface and FAHP algorithm, model development, evaluation, and analysis results. Fig. 2 illustrate the phases of this research. At the first phase, a literature review had been done on aesthetic domain, including the process of measuring interfaces and what does it took into consideration for measurement. As a results, the design principles that will be applied in designing web interfaces had been selected which are contrast, balance, alignment, simplicity and consistency.

Alignment is the principle that depict the alignment of elements in the interface whether in horizontal or vertical sense. Centered, justify, flush left and flush right are the four (4) types of horizontal alignment. Aligning interface elements will help create a more cohesive web page and make it easier for the user to use the website.

The principle balance is the way a designer uses the elements in a design. Pictures or shapes are among the most commonly used elements by the way of the sizes of the picture or the size of the shapes use in the design. This is attributed by perception that large elements are consider heavier than their small counterpart. Balance can be design in three (3) ways; symmetrical, asymmetrical and discordant or off-balance. A balance design is easier on the eye and it create a pathway for the eye to focus on the design.

The use of contrast in design can be applied through many elements such as color, size, shapes or direction. It is an important aspect in influencing the ability of user

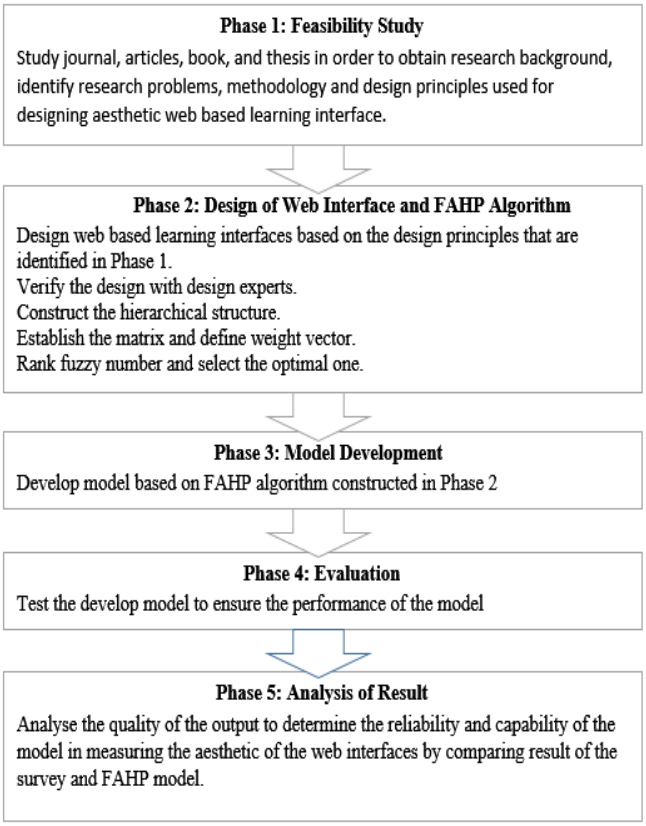

Figure 2: Phases of research methodology

to scan through the design. It also creates a visual hierarchy of the page by presenting the layout in a way that guide the user towards primary points of interaction and the following. Contrast is effective in capturing user attention and are easy to utilize as it is among the commonly used principle of design. Without the use of

proper contrast, the website can be hard to read and may create difficulties to visually challenge individual. Simplicity is the principle of minimizing a design. In graphic design, simplicity is best to achieve the best result. Simplified design ensure that the message is clearly understood by the user and not to be confused with other elements in the website. Simplicity incorporates other principles such as balance to create a harmony in a design and it is not only about removing unnecessary element in a design. For the user, this principle helps them to work effortlessly and more proficient.

Consistency or consistent design is important in a design as user tends to stick to something that is familiar to them and rarely choose to adapt to something new. Consistency is about how design should stay the same way throughout the site. A design that is consistent from the start to the end is preferable than an interface that switches elements between each page. An interface should avoid being confusing, a user may become frustrated if the navigation of the interface keeps on changing. There four (4) types of consistency, they are visual, functional, internal and external consistency.

The second phase is to design interfaces based on the design principles selected at the Phase 1. The design will be used combinations of design elements (such as font color, background color, font size and others) to form each of design principle that applied in the designing web interfaces. Then, the completed design will be evaluated by the experts in web design. The experts will be choosing ten (10) the most aesthetic interfaces out of 20 interfaces given. This evaluation is important to filter the interfaces in order to ensure that the interfaces selected are aesthetic from the experts' views. The third phase is to develop the prototype based on the FAHP approach.

The fourth phase is evaluation phase by the participants. Around 40 participants among higher education students will be participated in this evaluation. The participants are required to evaluate and rank the interfaces and to answer the questionnaire as well. The purpose of the questionnaire is study the effect of the interfaces on the user's satisfaction, user's engagement and ease of interface used. This is because previous studies indicates that there is a link between the usability of the web and the web aesthetics [39,40]. The first criteria, user's satisfaction refers to the level of like the user have to the interface, whereas user engagement is about how engage the user is with the interface and can be measure by the time the user spends on the website. Meanwhile, ease of use refers to how easy it is for end user to use the interfaces. This research intends to study the effect of interface design based on principles selected and how it effects the user perception on these criteria. During the evaluation, the interfaces will be displayed using the prototype developed in third phase. The evaluation will be performed in a controlled environment to avoid bias result.

The fifth phase which is the final phase, the data obtained from the evaluation, will be analysed that it will become the outcomes of this study.

V. EXPECTED OUTCOME

The expected outcome of this study is to produce a model that enables the measuring of aesthetics of web interface objectively and to provide a more reliable and robust decision in web interface evaluation. In addition, the study could produce a guideline in designing an aesthetic interfaces based on the design principles.

VI. CONCLUSION AND DISCUSSION

This research aims to design web-based learning interfaces based on the selected aesthetic design principles and develop a model for measuring aesthetic web-based learning interfaces based on the FAHP approach. FAHP were used in many fields and not widely used in Human Computer Interaction domain. The fuzzy element in FAHP counter the vagueness of human elements in choosing the most aesthetic interface. There are quite a number of design principles for designing interface, however, this study applied four (4) design principles which are contrast, balance, alignment, simplicity and consistency. The expected results of this research is to produce a model for measuring aesthetic of web interface, in which this model could provide measurable and more reliable decision in web interface aesthetic aspect. This model can be used as a guide for future designer in designing interfaces that conform to the aesthetic principles. Interface aesthetic is important as it relates to the usability of the interface. An interface that is aesthetic is more pleasing to use and in turn will be more usable.

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REFERENCES

[1] G. Lindgaard, G. Fernandes, C. Dudek, and J. Browñ, "*Attention web designers: You have 50 milliseconds to make a good first impression*!," Behav. Inf. Technol., vol. 25, no. 2, pp. 115–126, 2006.

[2] A. Mardani, A. Jusoh, and E. K. Zavadskas, "*Fuzzy multiple criteria decision-making techniques and applications – Two decades review from 1994 to 2014*," Expert Syst. Appl., vol. 42, no. 8, pp. 4126–4148, May 2015.

[3] J.-F. Chen, H.-N. Hsieh, and Q. H. Do, "*Evaluating teaching performance based on fuzzy AHP and comprehensive evaluation approach*," Appl. Soft Comput., vol. 28, no. C, pp. 100–108, Mar. 2015.

[4] Schnitman and Ivana, "*The dynamics involved in web-based learning environment (wle) interface design and human-computer interactions (hci): connections with learning performance*," 2007.

[5] J. Kim and J. Y. Moon, "*Emotional usability of customer interfaces*," in CHI '97 extended abstracts on Human factors in computing systems looking to the future - CHI '97, 2006, p. 283.

[10] D. C. L. Ngo, L. S. Teo, and J. G. Byrne, "*Modelling interface aesthetics*," Inf. Sci. (Ny)., vol. 152, no. SUPPL, pp. 25–46, Jun. 2003.

[11] [11] R. Parizotto-Ribeiro and D. N. Hammond, "*What is Aesthetics anyway ? Investigating the use of the design principles*," Aesthetic Approaches to Human-Computer Interact. Proc. Nord. 2004 Work., pp. 37–40, 2004.

[12] C. Salimun, H. C. Purchase, D. R. Simmons, and S. Brewster, "*Preference ranking of screen layout principles*," in Proceedings of the 24th BCS Interaction Specialist Group Conference, 2010, pp. 81–87.

[13] J. M. Zain, M. Tey, and G. Y. Soon, "*Using Aesthetic Measurement Application (AMA) to measure aesthetics of web page interfaces,"* in Proceedings - 4th International Conference on Natural Computation, ICNC 2008, 2008, vol. 6, pp. 96–100.

[14] J. M. Zain, M. Tey, and Y. Goh, "*Does aesthetics of web page interface matters to mandarin learning?*," IJCSNS Int. J. Comput. Sci. Netw. Secur., vol. 7, no. 8, pp. 43–51, 2007.

[15] J. M. Zain, M. Tey, and Y. Goh, "*Probing a self-developed aesthetics measurement application (SDA) in measuring aesthetics of mandarin learning web page interfaces*," Jan. 2008.

[16] Z. (Jack) Jiang, W. Wang, B. C. Y. Tan, and J. Yu, "*The determinants and impacts of aesthetics in users' first interaction with websites*," J. Manag. Inf. Syst., vol. 33, no. 1, pp. 229–259, Jan. 2016.

[17] A. J. Lazard, I. Watkins, M. S. Mackert, B. Xie, K. K. Stephens, and H. Shalev, "*Design simplicity influences patient portal use: The role of aesthetic evaluations for technology acceptance*," J. Am. Med. Informatics Assoc., vol. 23, no. e1, pp. e157–e161, Apr. 2016.

[18] K. Reinecke and A. Bernstein, "*Improving performance, perceived usability, and aesthetics with culturally adaptive user interfaces,"* ACM Trans. Comput. Interact., vol. 18, no. 2, pp. 1–29, Jun. 2011.

[19] V. S. Moustakis, C. Litos, A. Dalivigas, and L. Tsironis, "*Website quality assessment criteria*," 2004.

[20] K. Reinecke et al., "*Predicting users' first impressions of website aesthetics with a quantification of perceived visual complexity and colorfulness*," in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '13, 2013, p. 2049.

[21] F. Ecer, "*A hybrid banking websites quality evaluation model using AHP and Copras-G: a Turkey case*," Technol. Econ. Dev. Econ., vol. 20, no. 4, pp. 757–782, 2014.

[22] E. Mu, S. Wormer, B. Barkon, R. Foizey, and M. Vehec, "*A case study of using AHP group decision making for eportfolio selection*."

[23] P. D. D. Dominic, H. Jati, and G. Kannabiran, "*Performance evaluation on quality of Asian e-government websites - an AHP approach*," Int. J. Bus. Inf. Syst., vol. 6, no. 2, p. 219, Aug. 2010.

[24] K. Vatansever and Y. Akgűl, "*Performance evaluation of websites using entropy and grey relational analysis methods: The case of airline companies,*" Decis. Sci. Lett., vol. 7, pp. 119–130, 2017.

[25] T. B. Yee, R. Ramlan, R. Hassan, S. Rokhmah, M. Shukri, and &rashidah Mokhtar, "*The evaluation of third party hotel booking website performance using Analytic Hierarchy Process (AHP),*" 2018.

[6] M. H. Stenalt and M. Godsk, "*The Pleasure of E-Learning – Towards Aesthetic E-Learning Platforms*," Proc. 12th Int. Conf. Eur. Univ. Inf. Syst., no. April 2015, pp. 210–212, 2006.

[7] P. J. Lynch and S. Horton, "*Web style guide : basic design principles for creating Web sites***"**. Yale University Press, 2008.

[8] D. C. L. Ngo, "*Measuring the aesthetic elements of screen designs*," Displays, vol. 22, no. 3, pp. 73–78, Jul. 2001.

[9] D. C. L. Ngo, L. S. Teo, and J. G. Byrne, "*Formalizing guidelines for the design of screen layouts*," Displays, vol. 21, no. 1, pp. 3–15, Mar. 2000.

[26] R. Garg and D. Jain, "*Fuzzy multi-attribute decision making evaluation of e-learning websites using FAHP, COPRAS, VIKOR, WDBA*," Decis. Sci. Lett., pp. 351–364, Mar. 2017.

[27] K. H. Ramanayaka, X. Chen, and B. Shi, "*Identifying relative weights of evaluation indices for library website usability acceptance model by applying the Extent Analysis Fuzzy AHP approach*," Int. J. Web Appl., vol. 10, no. 4, p. 137, Jan. 2019.

[28] I. Masudin and T. E. Saputro, "*Evaluation of B2C website based on the usability factors by using Fuzzy AHP & hierarchical Fuzzy TOPSIS*," in IOP Conference Series: Materials Science and Engineering, 2016, vol. 114, no. 1.

[29] R. Anggrainingsih, M. Z. Umam, and H. Setiadi, "*Determining e-learning success factor in higher education based on user perspective using Fuzzy AHP*," MATEC Web Conf., vol. 154, p. 03011, 2018.

[30] W. C. Chou and Y. P. Cheng, "*A hybrid fuzzy MCDM approach for evaluating website quality of professional accounting firms*," Expert Syst. Appl., vol. 39, no. 3, pp. 2783–2793, 2012.

[31] S. Kubler, J. Robert, W. Derigent, A. Voisin, and Y. Le Traon, "*A state-of the-art survey & testbed of fuzzy AHP (FAHP) applications*," Expert Syst. Appl., vol. 65, pp. 398–422, 2001.

[32] W. . Lee, H. Lau, Z. Liu, and S. Tam, "*A fuzzy analytic hierarchy process approach in modular product design*," Expert Syst., vol. 18, no. 1, pp. 32–42, Feb. 2001.

[33] T. L. Saaty and L. G. Vargas, "*Models, Methods, Concepts & Applications of the Analytic Hierarchy***"** Process, vol. 34. Boston, MA: Springer US, 2001.

[34] L. A. Zadeh, "*Fuzzy sets*," Inf. Control, vol. 8, no. 3, pp. 338–353, Jun. 1965.

[35] J. A. Gatto, A. W. Porter, and J. Selleck, Exploring visual design. Davis Publications, 1987.

[36] McClurg-Genevese, "*The principles of design*", Digital Web, 2005. [Online]. Available: http://www.digital-web.com/articles/principles_of_design/.

[37] S. Levy, J. Yupangco, B. S. Levy, and J. Yupangco, "*A picture is worth 1000 words: visual design in e-learning,"* Learn. Solut. Mag., vol. 22, 2008.

[38] M. B. Harning and J. Vanderdonckt, "*Closing the gaps: software engineering and human-computer interaction. Workshop*," Ninth IFIP TC13 Int. Conf. Human-Computer Interact. (INTERACT 2003), no. July, 2003.

[39] N. Tractinsky, A. S. Katz, and D. Ikar, "*What is beautiful is usable*," Interact. Comput., vol. 13, no. 2, pp. 127–145, Dec. 2000.

[40] Shaikh, A., Ali, S., Memon, N., & Karampelas, P. (2010). SOA "*Security Aspects in Web-based Architectural Design***"**. In *From Sociology to Computing in Social Networks* (pp. 415-430). Springer, Vienna.