Exploring the effects of visual aesthetics in e-learning for engineering students

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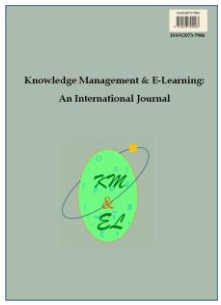

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Exploring the effects of visual aesthetics in e-learning for engineering students

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Abstract: e-Learning is changing the way students learn in the classroom. However, one of the least emphasised aspect in e-learning design concerns with aesthetics. Recent research in multimedia aesthetics highlighted the need to understand interaction from a multidisciplinary perspective. Aesthetics research in e-learning usually focuses on exploring the effects of positive aesthetics design towards neutral designs and a gap in exploring the effects of negative aesthetics. In this study, two different designs were developed to reflect positive and negative aesthetics designs. The cognitive outcome of these designs was compared and evaluated based on a learning achievement to measure comprehension. Gender and academic achievement were also explored to investigate if these factors had an effect on aesthetics perception and learning achievement. Based on the outcome of 95 electronic engineering students from two different polytechnics in Malaysia, it was found that engineering students performed better in the negative design in comparison to the positive design. In addition, genders or academic achievement differences were found not to influence the outcome.

Keywords: Emotional design; e-Learning; Aesthetics; Multimedia; Learning achievement

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1. Introduction

How do we define aesthetics? A simple *Google* search would depict aesthetics as physical characteristics that relates to beauty, attractiveness, and stylishness. According to Maity, Madrosiya, and Bhattacharya (2016), aesthetics is a philosophical branch that relates to the design and awareness of beauty. Therefore, the perception of aesthetics is inevitably subjective and challenging when the focus is to design for aesthetics. The common practice is to evaluate how humans define their interaction through their sensorial input such as sight, sound, smell, taste, and touch. This method is not farfetched from the basic learning method of how we experience the world, yet the perception of aesthetics may only be fully comprehended if users' life experience and their culture are also taken into account (Austring & Sørensen, 2012).

In e-learning, the design and application of multimedia elements for graphical user interface (GUI) has been widely used to understand how aesthetics influences interaction online (Maity et al., 2016). Aesthetics, when integrated through multimedia is seen as a method to influence users' senses and perceptions (Neo, Neo, & Yap, 2008). Aesthetic is vital as it influences perceived usability and the overall online user experience (Maity et al., 2016), thus a beneficial element in designing effective e-learning tools (Tharangie, Kumara, Jayasinghe, Marasinghe, & Yamada, 2008; Tractinsky, 2013). The value of aesthetics has cross multidisciplinary fields and has shown significant impact on online learning experience (Porter, 2017). Nevertheless, Grushka and Bellette (2016) added that learning online not only depends on the application of aesthetic multimodal elements but should also take into account users embodied digital experience. Thus, a need to explore aesthetics and why it is crucial to select elements that appeal to the users' senses and individuality. Nonetheless, without identifying a psychological link that relates multimedia to aesthetics, the benefits of aesthetics in the educational environment will be beyond our understanding (Soleymani, Yang, Irie, & Hanjalic, 2015).

To date research on aesthetic in multimedia-based learning mainly focuses on two areas; the application of emotional design theories (Norman, 2004) and comparing how emotions induced through multimedia-based emotional valance (smile – happy, crying – sad) influences learning outcomes. Hence, multimedia elements are differentiated based on the positive, neutral or negative value which is outlined by variations in colours, fonts, images, anthropomorphism, sounds, and music. Nevertheless, in education-based research, the common trend has been by comparing positive designs with neutral ones.

Positive designs are associated with elements that induces positive emotions such as bright colours, shapes and anthropomorphism (Mayer & Estrella, 2014; Um, Plass, Hayward, & Homer, 2011) whereas neutral designs are designs that neither reflects positive nor negative emotional valence (Plass, Heidig, Hayward, Homer, & Um, 2013).

Thus, based on the definition of neutral designs, some researchers like Tractinsky (2013) questioned the role of negative design or aesthetics. We question the possibilities of designing for negative aesthetics through dark dull colours as oppose to positive aesthetics that are designed based on bright warm colours (opposite). Is negative aesthetics favourable or detrimental towards learning outcomes? Heidig, Müller, and Reichelt (2015) highlighted the need to explore the effects of negative aesthetics on multimedia-based learning as it is still an understudied area in the academic circle. Secondly, by stereotyping e-learning designs to only portray positive designs, we will somewhat understate the influence of users' digital experience and preference. This is related to the concept of affordance which stipulates that the designing of a learning tool should not only be based on what the designers feel is the right design but should also be based on how the users would perceive these tools. Consequently, it is important to consider instructional design practices and affordance when designing an e-learning tool (Domagk, Schwartz, & Plass, 2010).

Next, personalizing a learning system may have beneficial impact on users' satisfaction as it accommodates to individual needs. With the advances of technology in e-learning, novel e-learning techniques that caters to different characteristics of students should be explored (Stark, Lassiter, & Kuemper, 2013). Thus, exploring the aesthetic preferences of engineering undergraduates would aid in identifying multimedia elements that may influences their learning experience. In this manner, the current study will also explore the differences between positive and negative aesthetic designs in regard to learning achievement and investigate if other factors such as gender and academic achievement have an interaction effect on these outcomes.

2. Literature review

2.1. Aesthetics

The word 'aesthetics' or '*aisthetikos*' is of Greek origins referring "*to perceive and to feel*" (Joshi et al., 2011). It refers to the interpretation and observation of beauty (Golombisky & Hagen, 2010). Hence, aesthetics defines the emotional experience between users and products (Suttle, 2011), and has strong ties with emotional design (Miller, Veletsianos, & Hooper, 2006). Aesthetics in product design have been found to be significant in web design (Fu, 2012), technical products (Candi, 2010) and even in ATM interface design (Tractinsky, 1997). Findings revealed that aesthetics positively influence usability, satisfaction, and perception. Good aesthetics triggers positive emotional experience (Sutcliffe, 2009) and this has been found to surpass usability (Tractinsky & Hassenzahl, 2005) and product quality (Mahzari & Ahmadzadeh, 2013).

According to Maity et al. (2016), one of the main issues in designing for aesthetics is that the subjectivity of every design which may not be fulfilling to everyone. It is a common understanding that one design may not be satisfying to all users. Which concurrently questions if personality influences how users perceive aesthetics and if culture has a moderating effect towards these attributes. Therefore, Soleymani et al. (2015) claims that in regard to online interaction, it is important to index multimedia

based on its usefulness, aesthetics properties and also understand how it may influence the emotional outcome of the interaction. Aesthetics in multimedia should take into account how it is represented as part of the learning contents (Maity et al., 2016). For instance, when text is used, the style, font, and colour of the text may have an impact on the overall aesthetics appeal, however we may question its relevance to the contents. When learning with media, aesthetics enables the instructional designer to tap into motivational and engagement needs of the user (Austring & Sørensen, 2012).

2.2. Aesthetics in e-learning development

Soleymani et al. (2015) highlighted that multimedia research is now redirected towards concepts that focus on the individuality of the user such as emotions, aesthetics, and perception. Therefore, unlocking a different area in human-computer interaction that incorporates multidisciplinary approaches such as psychology, digital humanities and also product design. In recent research, Peak, Prybutok, Mai, and Parsons (2017) claims that two aspects should be considered when visually designing an information system; *cognitive or behavioural* aspect that relates to usability and functionality and secondly the *pleasure (hedonism)* aspect that relates to user's experience associated to aesthetics (visceral) and emotions. This concept does not vary much from Norman's theory of emotional design that reflects upon three levels of user interaction; v*isceral, behavioural* and *reflective* and concurrently cognitive (behavioural) and affective (visceral) aspects of interaction.

Exploring the concept of aesthetics in multimedia based-learning has been explored as "*emotional design in multimedia*" by researchers such as Heidig et al. (2015), Mayer and Estrella (2014), Park, Knörzer, Plass, and Brünken (2015) and Um (2008). Heidig et al. (2015) specifically tried to investigate how expressive and standard aesthetics influenced learning outcomes and reported that the manipulation of such design elements to be unsuccessful especially in large sample size. Standard aesthetic is defined as the application of systematic and clear design strategies whereas expressive aesthetics are designs that are based on designers' creativity that may not conform to the standard design rules (Mbipom & Harper, 2009). According to, Tractinsky (2013), there is no universal guideline when designing for aesthetics. Designs are culturally motivated, subjective and varies based on individual life experience.

Nonetheless, it is still crucial to adapt aesthetics in e-learning tools (David & Glore, 2010). Empirical research found that aesthetics in e-learning promotes engagement (Stenalt & Godsk, 2006), usability (Parizotto-Ribeiro & Hammond, 2005), intrinsic motivation (Heidig et al., 2015), satisfaction (Hartmann, Sutcliffe, & Angeli, 2008) and, creates a positively enriching emotional experience (Chuah, Chen, & Teh, 2011). Visual aesthetics through colours, shapes, texture, font, and images are very influential in defining the perception of the learning tool (Hamdani, Hosseinpour, & Sharifuddin, 2012). Nevertheless, the application of aesthetics should always have an instructional goal (Mayer & Estrella, 2014). The use of multimedia elements for aesthetics should not solely be for decorative purpose as there is a high chance that these elements might disrupt the learning process (Clark & Mayer, 2008). Secondly, stereotyping aesthetics in the educational context is not pragmatic anymore (Austring & Sørensen, 2012). For instance, the use of bright warm colours as background or using specific fonts and size. On the other hand, designing based on aesthetics alone is not sufficient, the emotionality tied with each element should also be considered (O'Nolan, 2010). This is where emotional design is crucial. Designing for aesthetics with emotional influence is *emotional design* (Miller et al., 2006).

2.3. Emotional design in multimedia learning

In this study, the definition of emotional design in multimedia learning is as defined from previous studies by Heidig et al. (2015), Mayer and Estrella (2014) and Plass et al. (2013). Emotional design here is defined as a process of redesigning essential multimedia elements as defined in the Cognitive Theory of Multimedia Learning (CTLM) (Mayer, 2010) with emotionality so that the learning contents itself represents visual appeal and encourages meaningful learning. Essential elements are elements that are part of the instruction, where for instance a smiley ☺ could be used to represent a correct positive feedback. Emotionality is the aesthetic aspect of the multimedia elements. In previous studies in this area, bright warm colours, shapes, and anthropomorphism were used to represent positive design (aesthetics) that portrays happiness (emotions). However, the content of the courseware was based on general subjects such as "*how virus would attack*" and were aimed at undergraduates from various disciplines. Researchers compared positive designs against neutral ones and the learning outcomes were biased towards the positive design. We questioned if the attractiveness of the positive design alone played a determining role in these outcomes especially when a neutral design was a grey version of the positive design. Secondly, we are accustomed to colours in online interaction, so users embodied digital experience may negatively affect the perception of the neutral design. However, what if the colours used were darker in shade but equally attractive?

Ghali and Frasson (2010) found that joy (positive) and anger (negative) when designed based on emotionally affective voice tones and background music had similar effects on learning comprehension for participants between the ages 6 to 8 years old. Heidig et al. (2015) investigated the difference between positive and negative aesthetics on learning and found that it affected students' intrinsic motivation. It should be taken into account that the preference of colours and designs are also subjective to 'technology culture' which is defined as the universal preference of a design (David & Glore, 2010). Research also found that the effects of visual aesthetics on perception are also determined based on age, gender and education background (Harrison, Reinecke, & Chang, 2015). In regard to emotional design in online learning, Mcevoy and Cowan (2016) emphasis on the need to understand personalised user experience. Thus, we hypothesise, that there may be a similarity in preferences based on individuality such as gender and education background that may aid in the design process of the learning tool.

2.4. Gender and academic achievement

Culture has the potential to define how each gender perceives a certain colour or a visual stimulus (Plass et al., 2013). According to Barth (2012), female users are more receptive to colourful design and prefer aesthetics before usability. Mahzari and Ahmadzadeh (2013) claimed that female students preferred bright colours and male students preferred darker colours. In regard to academic achievement (CGPA), Jasper et al. (2012) claim that students who are high achievers have higher confidence in using an e-learning system however to date we have not found relevant literature relating to aesthetic preference of high achievers. In addition, Saleeb and Dafoulas (2011) also suggested exploring how, gender, the field of study and age may influence the variance in learning outcomes when positive and negative aesthetics are applied. Therefore, these two characteristics may influence the outcome of the study and was included to identify if there is an interaction effect between the variables.

3. Present study

According to Peak et al. (2017), it is important to develop systems that harmoniously integrates the functionality and aesthetic appeals. In this study, functionality which is defined by the interaction and contents of the courseware will remain constant. Positive and negative aesthetics will be represented by different colours and fonts. The study will first explore the effects of aesthetics in regard to emotional design towards learning achievement. Secondly, the effects of gender and academic achievement (CGPA) will be investigated to identify if it has an interaction effect on the learning outcome. Lastly, the interaction effect of these variables (design, gender, and academic achievement) will be investigated.

Therefore, the following research questions were developed to investigate the outcome:

RQ1*: Is there a significant difference between learning achievement between the positive and negative design?*

RQ2*: Is there a significant difference between genders for each design type towards learning achievement?*

RQ3*: Is there a significant difference between academic achievements for each design type towards learning achievement?*

RQ4*: Is there an interaction effect between gender, academic achievement and design type towards learning achievement?*

4. Methodology

4.1. Respondents

The respondents of this study were electronic engineering students from two different polytechnics in Malaysia. Prior to enrolling in any electronic courses, it was a regulation by the institutes that the students were not colour blind as such deficiency would deter their competencies in this field, for example, reading resistor band value. All the respondents were in their final year and were enrolled in the same course. The syllabus used for all Malaysian polytechnics are standardised thus the content of the courseware and the assessment method was deemed suitable for students in both institutions.

4.2. Instrument

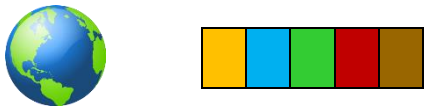
The instrument used to measure learning achievement was developed as per the Malaysian polytechnics syllabus for Integrated Circuit Design. The assessment was based on a multiple-choice objective test with 20 questions and was designed based on the guidelines of International Training and Education Centre for Health (I-TECH, 2010). Open-ended questions were not used in the development of the test as it was not suitable for non-native English Speakers. These types of questions will require respondents to respond or comment to question with their own words and by so the construction of answers would increase their cognitive load. The test covered the course syllabus for one week and was based on the course outline and objectives. Two content experts evaluated the validity of the test based on the syllabus. The learning achievement score was derived based on the differences between pre and posttest. Other details such as student ID number, gender, and academic achievement (CGPA) results were obtained through the

course instructor. From these data the respondents' academic achievements were categorised as either high (>3.99) or low (<3.00) CGPA for analyses purpose which was also recommended by Jasper et al. (2012).

4.3. Courseware design

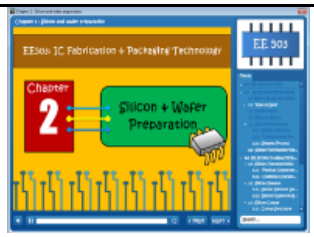
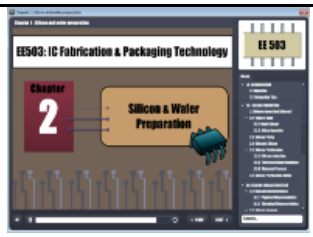
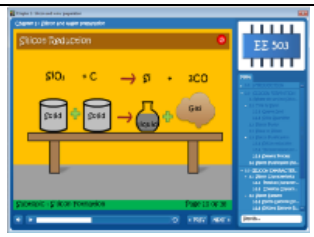
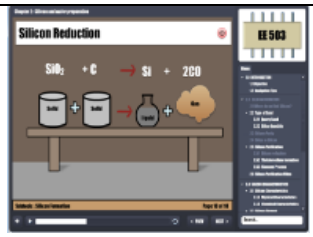
The graphical user interface for the design of the courseware is based on prior research relating to aesthetics, emotional design in multimedia learning and emotional induction using multimedia elements (Table 1) (Heidig et al., 2015; Mayer & Estrella, 2014; Plass et al., 2013). The selection of colours was based on the studies done by Dong (2007), Um et al. (2011), Zettl (2010), whereas the font type and size are based on studies by Shaikh (2009), Tsonos and Kouroupetroglou (2011), Zettl (2010) and lastly images based on the suggestions from Dong (2007) and Wang and Yu (2005). The selection of these elements is at par with the understanding that we are designing for aesthetics (beauty) and not deliberately selecting elements to fulfill the emotional valance category. Therefore, the selection of multimedia elements is based on empirical research that reflects on the positive and negative emotional characteristics that are simultaneously attractive at the same time. As an example, the font Impact has been found to reflect sadness (negative) and was also found to be perceived as attractive (Louch & Stork, 2013). Conversely, the use of anthropomorphism was found to be unnecessary as using sad smiley faces for the negative design was deemed not practical.

Table 1
Contextualisation of the design

Design	**Design characteristics**
Positive (Happy)	• Colour - High-energy warm or bright colours (yellow, orange and brown). Images are warmer.  • Font – Kristen ITC; size 15-24pt, 16pt most favorable.
Negative (Sad)	• Colour - Low brightness and dull colours (dark green, dull blue). Images are cooler.  • Font – Impact; size between 10 – 13pt and >24pt

All three designs had same narration, duration, and contents and were identical in interaction. The only variation was in regard to the graphical user interface aesthetics. Some of the contents such as videos, animation, and images were not changed and were similar in both designs. These were maintained as changes in colours would wrongly represent the content. For instance, the image of a silicon was maintained as grey-silver in all design and not altered as a different colour would represent a different object. Screenshots of the courseware are shown in Table 2.

Table 2
Screenshot of the courseware

Positive	Negative
	
	

The courseware was designed based on Frey and Sutton's Model for Developing Multimedia Learning Project (Frey & Sutton, 2010), Gagne's nine events of instruction and Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2010). The courseware was embedded with interactive activities for the retrieval and activation of short-term memory (Fig. 1).

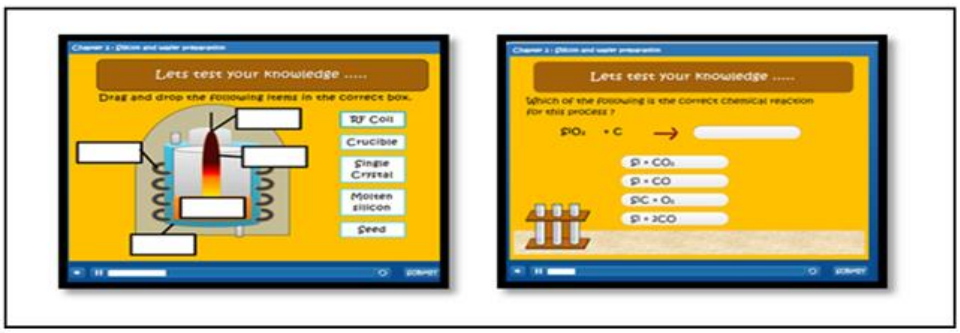


Fig. 1. Interactive activities in the courseware

The interface design for the coursewares were similar for both the designs. Navigational buttons (previous, next, replay, pause, play, volume control) and search option were designed for easy access to the content (Fig. 2). In addition, a menu bar at the right enables users to select topics and each slide has a progress indicator and subtopic indication.

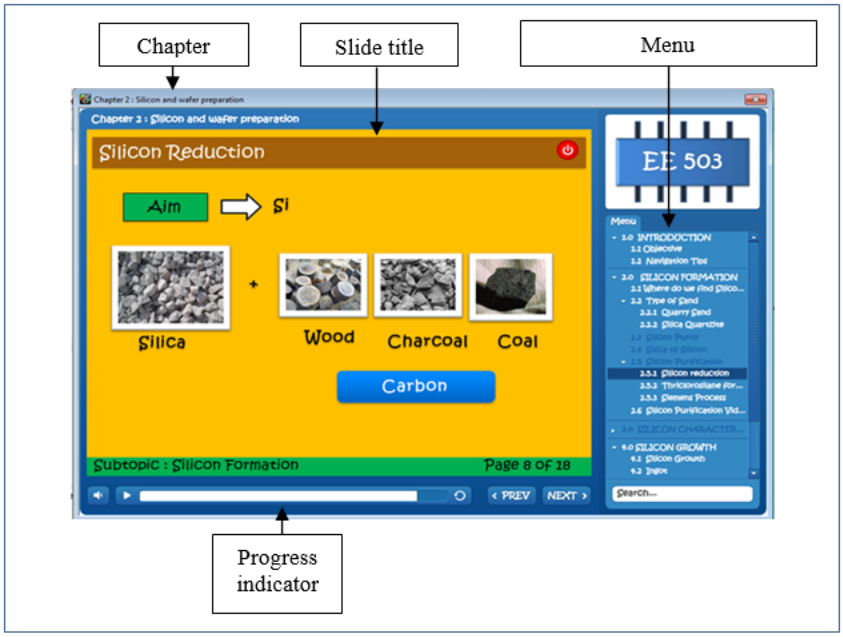


Fig. 2. Interface of the courseware

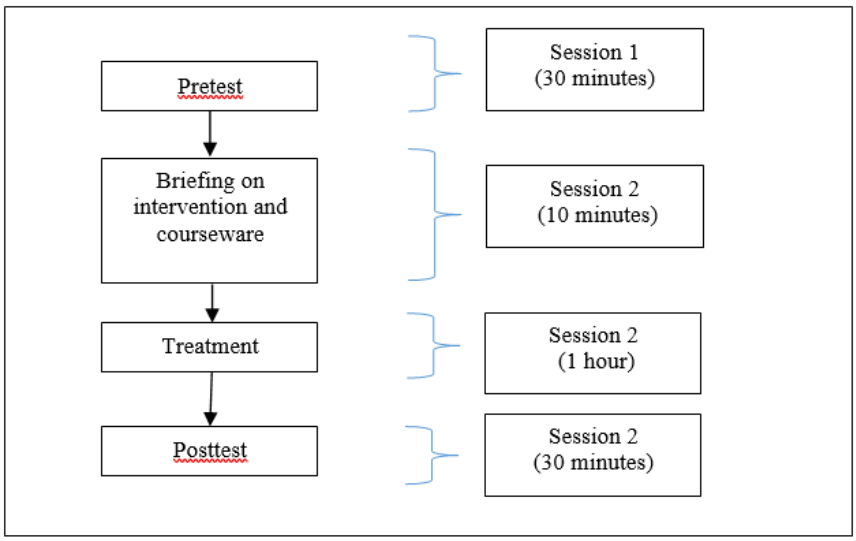


Fig. 3. Intervention procedures

4.4. Procedure

Each design was administrated in a different polytechnic to avoid communication between the respondents. The intervention was conducted by the lecturer of the class (familiar face) and not the researchers. Double-blind experimental method was used to ensure that the lecturers and respondent were not aware of the expected outcome of the study. In addition, to reduce Hawthorne effect, the researchers did not partake in the

execution of the procedures and just remain as an observer. Prior to the intervention, the researchers briefed the lecturers on the procedures.

The pretest and posttest were similar however varied in regard to items sequencing to avoid item memory practice. The pretest was distributed one week prior (session 1) to the intervention and students were not informed on the objective of the test to avoid pretest sterilization. Time allocated for the pre and posttest was 30 minutes. On the following week, a short briefing on the intervention and courseware were given to the students by their instructors. The duration of the courseware was 45 minutes, but an additional 15 minutes were provided to enable students to go through the contents. Next, the posttest was distributed directly after the intervention (courseware). The procedures of the intervention are graphically represented in Fig. 3.

5. Findings

Based on the total number of respondents of n=95, 53.7% were exposed to the positive design (n=51), 46.3% to the negative design (n=44). The demographic profile of the respondents are as in Table 3.

Table 3
Demographic profile of the respondents

Variables	n	%
Gender		
Male	55	57.9
Female	40	42.1
Age		
18-20	65	68.4
21-25	30	31.6
CGPA		
High (2.99 >)	43	45.3
High (2.99 >)	52	54.7

Normality was determined based on Central Limit Theorem where large samples that above 30 were considered to be normally distributed (Hair, Black, Babin, & Anderson, 2010). The data were homogenous at $F(1, 93) = .81$, $p = .777$ and were independently observed. Based on the learning gain (difference between pre and posttest) which is illustrated in Fig. 4, negative design had higher gain (mean= 5.77, s.d. = 1.57) in comparison to positive design (mean = 4.90, s.d. = 1.47).

Independent T-test performed on the data found statistically significant difference between the groups (mean =.871, s.e.= .312) on learning achievement at $t(93)=2.788$, $p=.006$. Using the same test, statistically significant difference was not observed between genders and CGPA groups at $t(1, 93) = .555$, $p=.580$ and $t(1, 93) = 1.706$, $p=.091$ respectively. In regards to the difference between how different genders perceived each design, no statistically significant difference were observed for the positive design ($F(1, 49) = .075$, $p=.786$) and also negative design ($F(1, 42) = .58$, $p=.811$). For CGPA, no statistically significant differences were observed for the positive design at $F(1, 49) = .572$, $p=.453$ and also negative design at $F(1, 42) = 1.112$, $p=.298$. A three-way ANOVA performed between gender, CGPA and design type concluded that there was no significant interaction effect between these variables at $F(1, 87) = .522$, $p=.472$.

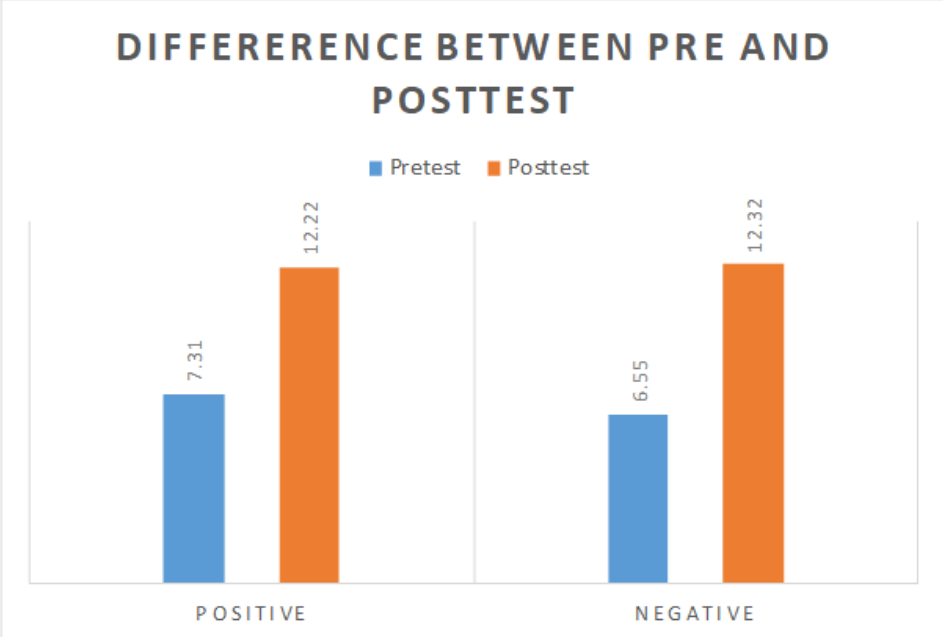


Fig. 4. Difference between pre and posttest

6. Discussions and conclusion

According to Austring and Sørensen (2012), aesthetics is important in conveying information that is sometimes difficult to be pictured by just using words. In e-learning, the application of aesthetics must have instructional goals and adapt to the digital experience and preference of the users. In the context of designing for aesthetics for engineering students, negative aesthetics were found to have better learning outcome in comparison to positive aesthetics. The difference in learning gain between positive and negative design were significant and negative design had higher learning gain in comparison to positive designs. In a study done by Saleeb and Dafoulas (2011), engineering students showed dislike towards colours such as yellow, red and brown (warm colours). However, they did like colours like purple and orange. It was also reported, that engineering students have a tendency to prefer dark colours or multimedia that refer to the 'out of space' matters (Kirkham, Farkas, & Lidstrom, 2006), thus relating to the negative design. This supports Chen, Jang, & Branch (2010), suggestion of developing interactive online learning tools that fosters students "feeling of affiliation" with the contents.

Based on the second and third research question, it was found that gender and academic achievement did not affect learning achievement online. The findings are similar to the findings of Jasper et al. (2012) and Kumar, Muniandy, and Yahaya (2016). In regard to the interaction effect between gender, academic achievement, and design type, it was found that these three elements together did not affect the learning outcome. Therefore, concluding that design of the learning environment for engineering students are only dependent on their overall preference of negative aesthetics or user interface as a whole and not based on their gender or academic achievement. Thus, the integration of

multimedia elements should be practical (Lee, Latchoumane, & Jeong, 2008) and catered to specific users' characteristics (Ahmad, 2012).

For this reason, research is currently expanding to understand how aesthetics influences cognition. Peak et al. (2017) described neuro-aesthetics as an evolving area that interlinks comprehension, perception and decision making that is based on visual aesthetics influence on cognitive neuroscience. On the other hand, Soleymani et al. (2015) added that new models should be developed to interrelate human-computer interaction, psychology and other fields in the hopes that cross-disciplinary research would further explore the emotional and cognitive effects of multimedia aesthetics. In conclusion, this study highlighted that in regard to engineering undergraduates, negative aesthetics are a better option in designing interface for e-learning tools as this preference is solely based on their academic discipline and not based on their gender nor academic achievement. Therefore, before an e-learning tool is designed, the first question always remains as "*who is it designed for*?"

7. Limitation and recommendation

The outcome of this study could be further improved by using a different sample of respondents (non-electronic engineering students) to understand the effects of aesthetics for different education background. Choosing a diverse sample and a general topic may be much more beneficial in understanding the difference between positive and negative aesthetics in online learning. The study only considered "short-term memory" testing that is learning gain because the contents covered is based on the syllabus requirement for the course. Even though the interface design of a learning environment has been shown to influence learning outcome, there is still limited research on defining attractive interfaces and ensuring that the design caters the preference of the users' aesthetics preference (Raihan, 2017). Therefore, we suggest the exploration of other characteristics in design such as sound and voice to understand the overall and individual effects of each design. As this study only focused on the cognitive learning outcome, other outcomes such as engagement, satisfaction, and motivation should also be investigated.

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