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Enhancing creativity through aesthetics-integrated computer-based training: The effectiveness of a FACE approach and exploration of moderators

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ABSTRACT

The majority of creativity enrichment research has focused on creative skills pertaining to originality which is assessed by divergent thinking tests. This study aimed to explore a new-paradigm for creativity enhancement—improving creativity through the FACE (Feedback, Aesthetic experience, Creative design, and Evaluation of designed products) computer-based training program in which aesthetic experience and 3-D creative design were incorporated. Moreover, possible moderators such as emotional creativity (EC) and desire for aesthetics (DA) were investigated during the training. In concurrence with these endeavors, 76 college students participated in a control-group experimental design study investigating the effectiveness of the FACE training; it was invented to promote cognitive aesthetic enhancement and improve creative performance on a 3-D coffee shop design. In addition, inventories regarding emotional creativity (EC) and desire for aesthetics (DA) were employed. The findings suggest that the employed training program enhanced college students' aesthetic understanding, and further improved their creativity through both conscious and unconscious processes. Notably, training that included constructive feedback led to better learning effects than the condition that included informational feedback. Furthermore, emotional creativity (EC) and desire for aesthetics (DA) played moderating roles during the learning process of creativity. This study provides a new archetype for improving creativity and the results support the possibility and importance of integrating aesthetics and creativity enhancement in computer based learning systems for modern educational methods.

1. Introduction

Creativity refers to the process of generating contextually or culturally original and valuable products (Yeh, 2017; Mayer, 1999; Shamay-Tsoory, Adler, Aharon-Peretz, Perry, & Mayseless, 2011); it requires both divergent and convergent thinking (Glăveanu, 2017). Although creativity development involves interactions of personal traits among other variables (e.g., family and school environment, working environment, customs, and social values), personal traits themselves remain among some of the most influential factors for creativity performance (Yeh, 2017; Valgeirsdottir & Onarheim, 2017). This consensus has led researchers of creativity development to include personal traits in empirical studies.

Much of the previously conducted creativity enhancement research involves the training of originality which is assessed by idea

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generation or divergent thinking tests (e.g., Fink et al., 2010; Scott, Leritz, & Mumford, 2004; Sun et al., 2016; Valgeirsdottir & Onarheim, 2017; Wei et al., 2014). However, the training of convergent thinking which is utilized in the assessment of valuableness, is often neglected. According to Glăveanu (2017), a critical sociocultural perspective advises against adhering to a single perspective, rather than considering perspectivism when evaluating creativity or developing creativity theories. The present study therefore holistically explores a new paradigm for enhancing creativity which focuses on both originality and valuableness, in addition to providing an interdisciplinary approach that evaluates two potential moderators—Desire of aesthetics (DA) and emotional creativity (EC).

The field of education is exploring new methods for appropriating computers, or other technological devices for the delivery of instruction, and the present researchers developed a multidisciplinary computer-based training program called FACE for accomplishing the instruction of creativity. The four components of FACE are as follows: Feedback, Aesthetic experience, Creative design, and Evaluation of designed products. In this approach, Science (computer science), Technology (multimedia and 3-D design), and Art (aesthetics and creativity) are integrated to offer a teaching method for the developing trend emphasizing STEAM (science, technology, engineering, art, and math), 3-D design, and maker-centered learning (Clapp & Jimenez, 2016; Saorín, Melian-Díaz, Bonnet, Carbonell, Meier, & De La Torre-Cantero, 2017). To date, few researchers have conducted such a multifaceted study pertaining to creativity. However, the close connection between aesthetics, design, art disciplines, and creativity has been documented in the relevant literature (Clinton & Hokanson, 2012; Saorín et al., 2017). These related findings suggest that incorporating elements of aesthetics into the present training may bolster creative design.

Moreover, two personality traits were included in this study: desire for aesthetics (DA), which pertains to one's personal attraction or motivation to seek out aesthetically appealing objects (Lundy, Schenkel, Akrie, & Walker, 2010), and emotional creativity (EC), which relates to an individual's ability to have emotional control and produce a variety of emotional responses (Oriol, Amutio, Mendoza, Da Costa, & Miranda, 2016). Based on previous research suggesting that motivation and EC act as moderators during creativity learning (Averill, 2009; Chad-Friedman, Lee, & Watson, 2018; Oriol et al., 2016; St-Louis & Vallerand, 2015), desire for aesthetics (DA) as a type of motivation, and emotional creativity (EC), were investigated as possible moderators for the outcome and effectiveness of the training employed in this study.

Briefly speaking, the investigation of the FACE approach combined aesthetics-integrated computer-based training with the analysis of personal traits. In addition, constructive feedback was evaluated as a potential mechanism for enhancing training effects in the exhaustive and interdisciplinary FACE program.

2. Literature review

2.1. Aesthetics, creativity, and design

Creativity is the process of generating contextually or culturally original and valuable products (Amabile, 1996; Yeh, 2017; Valgeirsdottir & Onarheim, 2017). Design spans across many domains and possesses correlations with creativity including the conception of original and valuable products, as well as creation stages which consist of preparation, problem identification, incubation, illumination, and then finally elaboration or verification (Clinton & Hokanson, 2012). Designers have been well acquainted with the pertinence of creativity within their domain. Researchers (Liu, Chang, Yang, & Liang, 2018) have stressed the significance of understanding the cognitive processes of creativity within the field of design research. Research findings have also suggested that a design-based course can enhance creativity through implementing creative strategies such as observing, brainstorming, synthesizing, prototyping, implementing, and hands-on practice (Bourgeois-Bougrine, Buisine, Vandendriessche, Glaveanu, & Lubart, 2017; Saggar, Quintin, Bott, Kienitz, Chien, Hong, Liu, Royalty, Hawthorne, & Reiss, 2017). These findings support the close relationship between creativity and design.

Some of the earliest investigations of the science behind aesthetics within the field of psychological theoretical and empirical research, was conducted by George D. Birkoff in the 1930's (Birkhoff, 1933; Myszkowski, Storme, Zenasni, & Lubart, 2014). Another contributor to the investigation of psychological interpretations of aesthetics was Eysenck beginning in the 1940's (As cited in Myszkowski, Storme, & Zenasni, 2016). Eyseneck explained individual differences of aesthetic judgement with two factors, ‘T’ which referred to good taste, and ‘K’ which is the preference for complexity. He theorized that ‘K’ could be associated with intelligence, but believed that artistic creativity was a personality trait, rather than a facet of intelligence (As cited in Myszkowski et al., 2016). More recently, Leder, Belke, Oeberst, and Augustin (2004) presented a comprehensive model of aesthetic experience that encompassed appreciation, emotion, and judgments. In the same vein, Myszkowski et al. (2014) suggested that aesthetic experience can be predicted by personality traits or cognitive abilities, and that aesthetic sensitivity is a cognitive ability that is driven by motivation for aesthetic concerns (Myszkowski et al., 2014).

Many of these theories presented, and even the history of aesthetic development, parallel creativity. Both phenomenon seem to be a driving force behind humanity that inspire invention and progress for modern society. Aesthetics and creativity are both deeply human processes that are dynamic, mysterious as research subjects, and have been discussed since the early philosophers yet still remain controversial. Previous studies have demonstrated that design is closely related to creativity, and designers make aesthetic decisions (Clinton & Hokanson, 2012). Therefore, one can make a logical connection from aesthetics to creativity. In addition, Saorín et al. (2017) explored these parallels and found that design, which is fundamental in aesthetics, improved creativity performance and they went on to say that proficiency in arts disciplines is just as important as technical knowledge for a professional engineer. Creativity is a necessary component of aesthetics because without it, art and design would lack novelty and usefulness. Likewise, creative products lacking aesthetic consideration would be less than desirable, and lack value or beauty.

2.2. Integrated computer-based enhancement training of creativity

Recently, Valgeirsdottir and Onarheim (2017) reviewed and provided a current consensus of the 22 quantitative studies of creativity enhancement that have occurred since 2004. They found methodological inconsistencies and disparities among measures and results. They reported that most creativity training programs thus far utilize divergent thinking, problem solving, performance, or attitude/behavior methods (respectively in order of prevalence) to improve creativity performance. Inconsistency regarding results and measurements were also observed, but the consensus is that creativity can be taught (Scott et al., 2004; Valgeirsdottir & Onarheim, 2017). Our study investigates the potential of integrating computer science, aesthetics, technology, and design, in addition to the employment of feedback, to improve creativity. The type of creativity explored in our training pertains to product design.

There is some consensus that aesthetic experience, such as aesthetic appreciation, perception, and emotional response, can be directly influenced by formal training (Silvia, 2006). Several researchers have attempted to represent these observations in empirical research across artistic domains (e.g., Locher, Smith, & Smith, 2001; Millis, 2001; Reber, Schwartz, & Winkielman, 2004; Silvia, 2006). This accumulation of findings suggests that art training does in fact alter the way a viewer would perceive and understand art and aesthetics.

With the advancement of technology becoming one of the highest priorities within our modern society, art in education has struggled to maintain legitimacy. The result is that educators have aspired to a new acronym that includes “A”, called STEAM. There are three possible definitions of the “A” in STEAM: either arts, aesthetics, or creativity (Clapp & Jimenez, 2016). While educators agree that the “A” does hold value, especially for creativity development, the implementation of “A” training within STEM holds challenges, and further advancement of methods is necessary (Clapp & Jimenez, 2016). Recently, some researchers have integrated the arts with STEM for gifted learners or investigated the relationship between student preferences of art and STEM subjects (Forbes, 2018; Wilson, 2018).

As for the employment of computer science and technology, Hung and Young (2017) found positive effects of using multi-touch technology to aid art appreciation education and motivation. Similarly, Saorín et al. (2017) found that the use of 3-D designing programs for 3-D printing, with digital editing and 3-D painting, did in fact improve engineer students' creativity. The use of 3-D designing software by engineers is common practice, and there is a logical connection between creativity, and designing or improving products. These findings support the current study utilizing technology and a 3-D interface to improve aesthetics and creative ability.

To maximize the training effects of creativity, mechanisms such as scaffolding, guided practice, positive feedback, and observational learning, are important concepts that were employed in the training program of this study. Scaffolding refers to an assistance that allows learners to complete tasks they can't finish independently; it helps learners move through the zone of proximal development (Eggen & Kauchhak, 2012); it has been suggested to be a critical component in the improvement of creativity skills (Kao, Chiang, & Sun, 2017; Yeh et al., 2012). In an experimental instruction that included a digital game with varied scaffolding designs to evaluate students' learning effects on physics knowledge acquisition and design creativity, the researchers (Kao et al., 2017) found that scaffolding contributes to effective learning. Extended from scaffolding, guided practice helps learners encode information into long-term memory (Eggen & Kauchhak, 2012) as well as knowledge transformation and knowledge creation during the learning of creativity (Yeh et al., 2012). It has been found that providing guided practice, increasing self-awareness, and encouraging mindful learning contributes to nurturing reflective practices and helps learners become more efficacious (Tillema, 2000; Yeh et al., 2011). Moreover, many empirical studies (e.g., Bosanquet & Radford, 2018; Gong & Zhang, 2017; Hennessey & Amabile, 2010) have confirmed the moderating and dynamic influence of feedback on creative performance. Feedback on creativity-related evaluation contributes to the enhancement of creativity dispositions (Yeh et al., 2012), which may result from enhanced self-awareness and mindful learning (Titone, Sherman, & Palmer, 1998). Finally, observational learning through peer evaluations of group assignments or assessing divergent thinking performances support the learning of creativity (Guerra & Villa, 2017; Yeh et al., 2012).

2.3. Personal traits, feedback, and creativity learning

2.3.1. EC and creativity

The theories of creativity (e.g., Sternberg, 2018; Valgeirsdottir & Onarheim, 2017) and aesthetics (e.g., Myszkowski et al., 2014; Myszkowski et al., 2016) suggested that personal traits are crucial for the learning of creativity and aesthetics. The present study sought to shed light on the potential effects of two personal traits (DA and EC) on creative performance. EC is a dispositional trait which largely represents the ability to experience complex combinations of emotions that are original and appropriate, and has been found to increase creativity and academic performance (Averill, 2009; Oriol et al., 2016). Averill (2009) claimed that EC includes emotional novelty, effectiveness, and authenticity; individuals with high EC can produce new, different, and effective emotional responses and can reflect on someone's true values and beliefs. Averill (1999) found EC to be correlated with openness to experience and extraversion.

To date, only a few studies have focused on the relationship between EC and creativity. Ivcevic, Brackett, and Mayer (2007) found that creativity correlated with self-reported measures of EC. Since the essence of EC lies in “emotion”, the role of EC during creativity performance can be interpreted from the perspective of emotion. Among the sea of ambiguity pertaining to brain processes involved in creativity, there is some consensus that emotion and motivation may facilitate or moderate the creative processes (Chad-Friedman et al., 2018; St-Louis & Vallerand, 2015; Yeh et al., 2016). It was observed that moderate changes of mood can affect cognition (Ashby, Valentin, & Turken, 2002), and that positive emotions may influence working memory, and further, influence creative processes (Yeh, 2017).

Positive mood states may also stimulate creativity by the release of the neurotransmitter noradrenalin and increase working memory capacity (Ashby et al., 2002; De Dreu, Baas, & Nijstad, 2008). Creativity has been found to be closely associated with working memory capacity (Yeh et al., 2014, 2016; Yeh, 2017) which holds transient information and facilitates comprehension, thinking, and planning (De Dreu et al., 2008). A more recent fMRI study (Perchtold et al., 2018) suggests that emotion and classic divergent thinking utilizes similar cognitive operations (Perchtold et al., 2018). Therefore, implications from emotion studies and neuroscientific theories suggest that EC may contribute to the release of neurotransmitters noradrenalin and dopamine, which then stimulate cognitive processes involved in creativity, such as emotional regulation, efficiency of working memory, and original ideas.

2.3.2. DA and creativity

Within the broad field of education, desire or motivation has been a subject of investigation because of its moderating effects on performance. There is a body of research suggesting that intrinsic motivation is beneficial in education and serves many long term benefits pertaining to engagement, conceptual understanding, comprehension, and interest (Chad-Friedman et al., 2018; Hennessey & Amabile, 2010; Vansteenkiste, Lens, & Deci, 2006). DA, as one of the main focuses of this study, refers to a general type of intrinsic motivation pertaining to all beauty. Lundy et al. (2010) assumed that aesthetic motivation would likely span across domains; an individual who expresses a high level of aesthetic desire may also experience altered states of wonder or awe in the wake of beauty, relative to individuals who are less aesthetically motivated. Based on the culmination of three experiments including 232 varied participants, Lundy et al. (2010) developed the Desire for Aesthetics Scale (DFAS) to measure aesthetic motivation. The researchers in the present study utilized this aesthetic inventory because it can serve as an accurate measurement of general aesthetic motivation and awareness of beauty, regardless of artistic training, or chosen area of expertise.

In combining motivation with DA, perhaps a bit of art training exposure could increase natural intrinsic motivation or DA. Several researchers have found that viewers preferred art that they understood and can easily process (Reber et al., 2004; Silvia, 2005, 2006). The more a person understands and is exposed to art, the more likely they will find it beautiful and enjoyable, and in turn, their tastes will become more sophisticated as they learn to enjoy more creative art; such cycled learning may, further, enhance creativity. Moreover, expert artists reported art to be more interesting, or complex, and viewing art inspired a positive feeling of understanding, which leads to positive aesthetic emotions (Locher et al., 2001; Millis, 2001; Silvia, 2005, 2006). Therefore, DA should facilitate the learning of aesthetics and creativity.

2.3.3. EC, DA, and feedback on the learning of aesthetics and creativity

One central concern of this study is to shed light on the interactive relationships between EC, DA, feedback, and the learning of aesthetics and creativity. Two types of feedback were provided in the training of our study: positive feedback through expert aesthetic judgements, and the sharing of creative designs through peer-evaluation of designed products. Many empirical studies (Gong & Zhang, 2017; Hennessey & Amabile, 2010) have explored the moderating role of affect and feedback on creative performance, and it has been observed that feedback has a dynamic and strong influence on inducing positive affect.

A recent study (Gong & Zhang, 2017) found that supportive supervisor feedback that induced positive affect indirectly promoted creativity. Along the same lines, Fink et al. (2010) found that presenting individuals with the ideas of others stimulated new ideas and increased creativity. Such a training strategy facilitated bottom-up processing through the use of semantic integration, memory retrieval, and attention. These findings support the idea generating techniques employed in the present study including exposure to expert aesthetic judgements, and the designs of others. These learning experiences may result in inspiration, and improved creativity.

On the other hand, Sun et al. (2016) investigated creativity enhancement through a fMRI; they found that after 20 training sessions, participants had statistically improved their divergent thinking abilities and concluded that improved creativity may result from posterior brain regions, and processes involved in top-down cognitive control (Sun et al., 2016). A recent fMRI study (Yeh et al., 2018) also found that rich expertise related to the integration of external sensation, internal states, top-down attention, reward processing, and emotion regulation. Accordingly, informative or constructive feedback during training may enhance expertise and facilitate learning through bottom-up and top-down cognitive processes.

In addition, positive affect may increase creative problem solving (Yeh et al., 2016) through effective self-regulation, cognitive flexibility, recall, and motivation (Ashby et al., 2002; Aspinwall, 1998). These cognitive improvements resulting from emotion can be explained through neuropsychological theories (De Dreu, Baas, & Nijstad, 2008; Perchtold et al., 2018). Ashby et al. (2002) explain these changes to be a result of elevated mood from increased levels of dopamine in the frontal cortical areas associated with reward. Accordingly, constructive feedback may enhances positive emotions through reward systems. Based on the aforementioned dynamic relationships between EC, positive emotion, DA, motivation, aesthetics, and creativity, it's reasonable to speculate that constructive feedback during training may develop deeper understanding and magnify the influence of EC and DA on aesthetics and creativity performance during aesthetic-integrated training.

2.4. The present study

Much of the creativity enhancing research that has been conducted involves employment of divergent thinking in object related tasks (e.g., Fink et al., 2010; Sun et al., 2016; Wei et al., 2014). In this study, we proposed a new method for improving participants' creativity by exposing them to aesthetics-integrated computer-based training that would enhance their understanding of aesthetics, aesthetic experience, relationships among creativity and aesthetics, and product design; the researchers speculated that this instruction would improve their aesthetics and creativity in a 3-D coffee shop design. Notably, a FACE (Feedback, Aesthetic experience, Creative design, and Evaluation of creative design) computer-based training program designed by the researchers was employed.

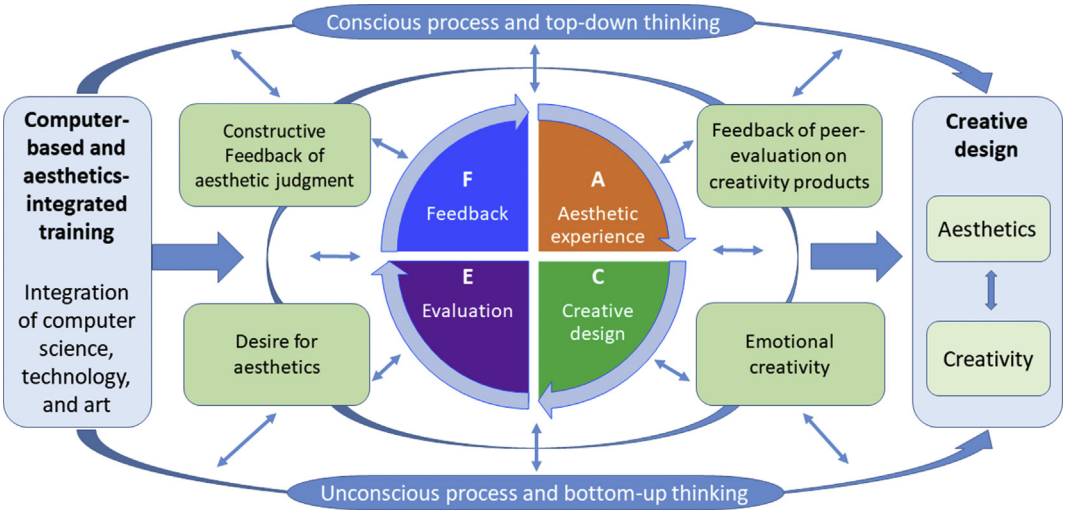

Fig. 1. The hypothesized model of how aesthetics-integrated computer-based training influences creativity learning.

Feedback refers to constructive feedback that includes exposure to experts' opinions in aesthetic judgements and idea sharing through peer-evaluation on the 3-D designed products. *Aesthetic experience* is the process of learning about art or aesthetics and experiencing those concepts with an outcome of aesthetic judgment. *Creative design* is the practical application through 3-D design of learned concepts in the training. *Evaluation* refers to assessment of the aesthetics and creativity of personal work and the work of others in the 3-D design.

The treatment of constructive feedback was employed in the training. We postulated that constructive feedback would facilitate the training effect through enhanced conscious learning; moreover, the training would improve participants' aesthetic and creative ability through both bottom-up (Fink et al., 2010) and top-down thinking (Sun et al., 2016), as well as unconscious and conscious processes. In addition, this study sought to shed light on the effects of the personal traits of EC and DA on aesthetic ability and creative performance. Based on the aforementioned findings, we assumed that EC and DA would interact with the treatment in the training, especially the constructive feedback, and then enhance positive emotion, motivation to learn, emotional regulation, planning, efficiency of working memory, and original ideas in creative design during the training. In other words, these personal traits would moderate the learning process of aesthetics and creativity in the training through both the conscious and unconscious processes. The hypothesized model is illustrated in Fig. 1.

The following hypotheses were proposed in this study:

- H1: All participants improve aesthetic ability after experimental training with participants receiving constructive feedback outperforming those receiving only informational feedback.
- H2: All participants improve creative ability after experimental training with participants receiving constructive feedback outperforming those receiving only informational feedback.
- H3: Emotional creativity (EC) is a moderator in aesthetic training and participants reporting higher levels of EC outperform those with lower levels of EC in evaluated aesthetic ability.
- H4: Desire for aesthetics (DA) is a moderator in aesthetic training and participants reporting higher levels of DA outperform those with lower levels of DA in evaluated aesthetic ability.
- H5: Emotional creativity (EC) is a moderator in creativity training and participants reporting higher levels of EC outperform those with lower levels of EC in evaluated creative ability.
- H6: Desire for aesthetics (DA) is a moderator in creativity training and participants reporting higher levels of DA outperform those with lower levels of DA in evaluated creative ability.

3. Method

3.1. Participants

Purposive sampling through campus advertisement was employed to include 95 undergraduate students. Seventy-six participants were included in the final analysis because 19 of the participants withdrew enrollment due to illness or scheduling conflicts, or were omitted based on invalid inventory data (e.g. all 1s or 6s). The sample composed of 36 males (47.4%) and 40 females (52.6%) with an average age of 20.03 (ranging from 18 to 23, $SD = 1.177$). No participants were seeking art-related degrees.

The participants were randomly assigned to the control ($N = 41$, 53.9%) or the experimental group ($N = 35$, 46.1%). The study was approved by the Research Ethics Committee of the university where the study was conducted, and written informed consent was obtained from all participants. Approximately $50 USD were rewarded for participation in the whole experiment.

3.2. The learning system and materials

An internet version of The Learning System of Improving Creativity through Aesthetic Experience (LS-ICAE) was developed by E-prime as well as the website languages of PHP and MySQL. In the learning system, computer science, technology, aesthetics, and creativity were integrated, and four components of FACE (Feedback, Aesthetic experience, Creative design, and Evaluation) were emphasized. The FACE training program, developed based on theories of educational psychology, aesthetic experience and creativity, was developed by the research group (the principal investigator with over 20-years of experience in creativity studies, two PhD students, and one programing engineer) through months of discussions and brainstorming. The interventions with regard to aesthetics in the FACE training program were also reviewed by two experienced junior high school art teachers.

The LS-ISAE consisted of three main parts: the pretests, the training courses, and the posttests. The pretests included the measure of background information, DA, EC, and the pretest of creativity (coffee shop design). The training course consisted of 6 sections which lasted for 100 min in total. The posttests consisted of the posttest of creativity (coffee shop design) and a reflection questionnaire. The assumption of this training course was that through the FACE processes, the participants' aesthetic and creative cognition would improve, which would further enhance their creativity.

The training course integrated the use of multimedia, pictures, and texts. Six sessions were included: (1) What is beauty: 6 films were provided to illustrate what beauty is and how it's related to creativity. (2) Color and association: Slides introducing the association of colors, emotions, and cognition were shown first. Then, paired pictures and questions were displayed to guide color association practices. (3) Color combination and harmony: Slides introducing the color aesthetics were presented first. Then, pictures and questions were posted to guide practices on evaluations of color harmony, aesthetics, and creativity. (4) Picture and text composition in ads: Paired ads were shown with explanations of why one was better than the other. Then, questions were displayed to guide practices on analyzing clearance of information, attention level, beautifulness, and creativity. (5) Emotional expression and product design: Pictures of well-designed everyday products with touching descriptions were presented to enhance the association of emotions, aesthetics, and creativity. (6) Creativity, aesthetics, and space design: Important concepts of good design were introduced. Then, pictures and questions were posted to guide practices on evaluating beauty of humanity, manifestation, space, spirituality, and transcendence. The instruction included 215 slides in total.

3.3. Instruments

The learning results or concerned variables of this study were measured by two inventories: one creativity test and one questionnaire (see Table 1). The questionnaire consisted of the Desire for Aesthetics Scale (DFAS) and the Emotional Creativity Inventory for College Students (ECI-CS). With the permission of the authors, the Desire for Aesthetics Scale (DFAS) (Lundy et al., 2010) was revised to measure individual variation in aesthetic motivation (see Appendix A for test items). The Emotional Creativity Inventory for College Students (ECI-CS) (Lee & Yeh, 2009), was revised based on Averill's (1999) EC Inventory and used to assess participants' EC.

The creativity test was developed by a 3-D software called Unity and through peer evaluation, it measured aesthetic and creative ability in the designing of a coffee shop. The employment of peer evaluation was based on the consensual assessment technique (CAT), which is usually done individually without giving specific rubrics. With its great ecological validity, CAT has been commonly used in creativity assessment (Hennessey, Amabile, & Mueller, 2011). During the design activity, the participants chose 12 objects from a list (e.g. tables, chairs, lamps, etc.) and the materials that objects were made out of; the participants could also change the color, direction, and size of the chosen objects. The participants were asked to type a name for the designed coffee shop; they were also told that the designed shop would be peer-evaluated based on two indices: aesthetics and creativity. The time limit for the design was 30 min. Finally, the reflection questionnaire consisted of 20 items in total (see the results section for questions) and was employed to understand how the participants felt about the training.

3.4. Experimental design and procedures

The aims of this study were to examine whether the FACE training (Feedback, Aesthetic experience, Creative design, and Evaluation) would improve the participants' aesthetic and creative cognition as well as creative ability, especially when constructive feedback was provided. Moreover, this study aimed to examine the moderation effects of DA and EC on the improvements of aesthetics and creativity. To achieve our goals, a control-group pretest and posttest design was employed to achieve the goals of this study. According to treatment fidelity studies (e.g., Borrelli et al., 2005; Capin, Walker, Vaughn, & Wanzek, 2017), treatment fidelity should include indices of treatment design, training providers, delivery, receipt of treatment, and enactment of treatment skills. The present study included all of these indices to ensure the treatment fidelity in our training.

All data were collected in a computer lab by two training providers. After a brief instruction, the participants were randomly assigned to the control group or the experimental group. Then, they took the pretests (the ECI-CS, DFAS, and first coffee shop design) and received the FACE training course. Following the training, the participants took the posttest (second coffee shop design) and a reflection questionnaire. The pretest and posttest were employed to measure improvement of aesthetics and creativity; the reflection questionnaires were employed to assess the participants' learning effects and their feelings toward the interventions during the training. All test responses were recorded and response times were controlled. To avoid exhaustion, a 10-min break was granted before and after the training course. The completion of the whole experiment, including instructions, signing documents, and debriefing, took about 4.5 h (see Fig. 2).

Table 1
Instruments for concerned variables.

Measured variables	Desires for aesthetics	Emotional creativity	Creativity	Training effect
Instruments	DFAS (16 items)	ECI-CS (17 items)	Coffee shop design (2 items)	Reflection questionnaire (20 items)
Response options	1 (totally disagree) to 7 (totally agree)	1 (totally disagree) to 5 (totally agree)	1 (very weak) to 6 (very strong)	1 (strongly disagree) to 6 (strongly agree)
Factors and sampled test items (number of test items)	Factors: music (4); art and architecture (6); appearance and attraction (3); cognition and emotion (3) Test items: "I find beautiful faces very memorable"; "My moods are affected by the attractiveness of my surroundings."	Factors: emotional preparedness (5); novelty resources (5); effectiveness (3); novelty responses (4). Test items: "I can simultaneously experience different types of emotions"; "I can reflect on my past emotional experiences to help me deal with current emotional problems"	Peer evaluation based on consensual assessment technique Indices: Aesthetics; creativity	Dimensions: Feelings about the employed manipulation of feedback and the training effects (4); conscious thought devoted to each of the aesthetic facets (beauty of humanity, manifestation, space, spirituality, and transcendence) when designing the coffee shop (10); and opinion of each of the 6 training sections (6).
Factor loadings/Variance explained	.460 to .847 (see Appendix A for test items)/60.650%	.367 to .950/43.134%		
Reliability	Cronbach's α: (1) Total: .842; (2) Factors: .799, .750, .626, and .741, respectively.	Cronbach's α: (1) Total: .813; (2) Factors:.758, .717, .667, and .764, respectively	Correlation of experts' and peer-evaluation scores: (1) aesthetics: r = .825; (2) creativity: r = .713	

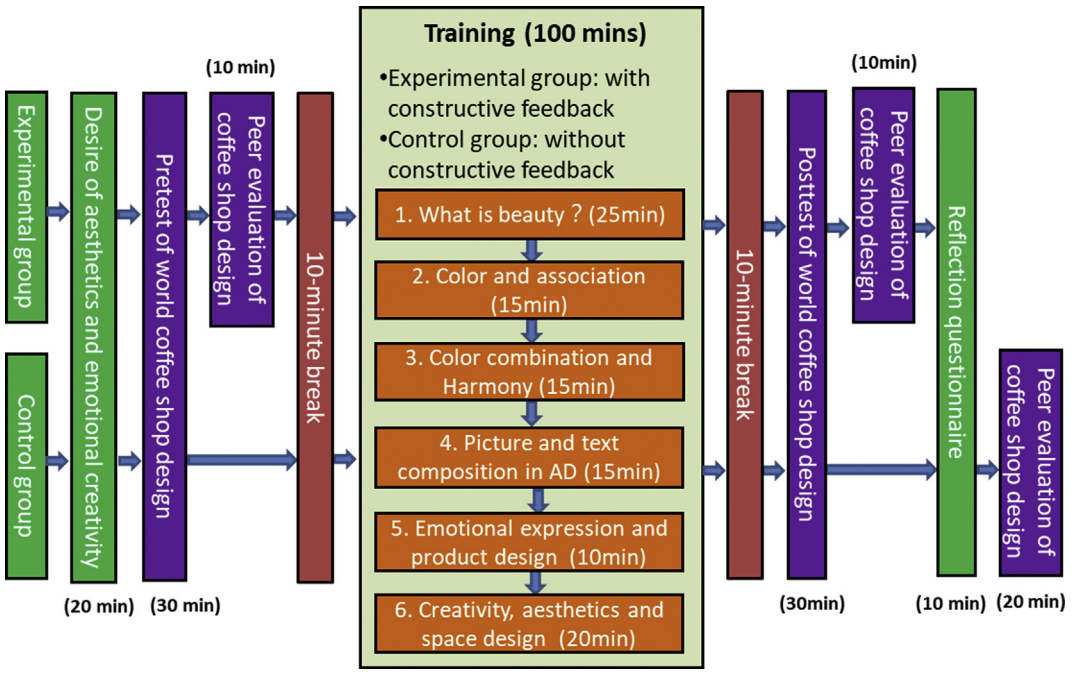

Fig. 2. Procedures of the experiment.

Both the control group and the experimental group received the FACE training, but different feedback was given to the experimental and control groups in the FACE training program. During the training, all the participants were scaffolded to learn concepts of aesthetics and creative design with plenty of guided practices though aesthetic judgments and answering questions, and then designed their own coffee shop. The fundamental difference between the two groups were that the experimental group was provided with constructive feedback, whereas the control group was only provided with informational feedback. We expected that while both groups would improve their creativity, the experimental group would improve more.

The constructive feedback was delivered in two ways. First, while going throughout the six sections of the intervention (beautifulness, color and association, color combination and harmony, picture and text composition, emotional expression and product design, aesthetics and space design), the experimental group was given constructive feedback (expert opinions about the material and explanation of why one aesthetic picture or design was superior to the other after they evaluated a picture or answered a question) whenever practice questions were posted. On the contrary, the control group was only given informational feedback (suggested answers without any explanations). The constructive feedback was designed to enhance awareness and analytical learning during the training. Second, the experimental group completed peer-evaluation immediately after the first and the second coffee shop design. By giving feedback to peers, the participants obtained creative ideas from viewing others' creative design. Such an observational learning might help idea stimulation and association. On the other hand, the control group was given the opportunity to peer-evaluate both the pre- and posttest coffee shop designs at the end of the experiment. For both groups, peer-evaluation on the coffee shop design were kept blind from personal identification and treatment interventions.

4. Results

4.1. Preliminary analysis

All of the data in this study was analyzed by SPSS 21.0. Twenty-one participants took aesthetics-related courses, with 16 participants in the control group and 5 participants in the experimental group. Such an experience was neither related to the pretest and posttest score of peer evaluation on coffee shop design with regard to aesthetics and creativity ($r = -.040$ to $.084$, $ps = .473$ to $.788$), nor related to the score of EC ($r = -0.107$, $p = .357$) or DA ($r = -0.213$, $p = .065$). Moreover, none of them had won design-related awards during the study in Junior high school and college.

Each coffee shop design (see Fig. 3 for examples) was evaluated by the participants and given a score which allowed for an average score out of 76 evaluations. This allowed participants to view others designs, and additionally provided the researchers with a reliable measure of aesthetic and creative quality. The subjectivity of aesthetics provides challenges for accurate scoring and these inconsistencies were neutralized by having a sufficient quantity of evaluations per design. Additionally, two experienced junior high school art teachers were invited to rate ten pretest pictures of the coffee shop design from the experimental group on aesthetics and creativity to test the reliability of peer-evaluation in this study. Averages of the experts' scores and the peer-evaluation scores of 41 participants on these coffee shop designs were significantly correlated, $r(9) = 0.825$ ($p = .003$) and $r(9) = 0.713$ ($p = .021$) for

Fig. 3. Example of coffee shop design.

aesthetics and creativity, respectively. These results showed a good reliability of the peer evaluation.

Furthermore, Pearson product-moment was employed to analyze the correlation between aesthetics and creativity. The results showed that in general, the pretest score of aesthetics was positively correlated with that of creativity, and the posttest score of aesthetics was positively correlated with that of creativity (r = 0.438 and 0.397, ps < .01). However, the correlations of aesthetics and creativity were more strongly correlated in the experimental group than in the control group in the posttest (r = 0.448, p < .01 vs. r = 0.330, p < .05).

4.2. Effects of experimental instruction

4.2.1. Group differences on improvements of aesthetic ability and creativity performance

This study used the scores obtained by peer evaluation for the design of a coffee shop to measure the participants' performance of creativity and level of aesthetics. Using Repeated Measure ANOVA with a 2 × 2 mixed design, we examined whether there were Group effects (Control vs. Experimental) on the participants' improvement of aesthetics and creativity. Fig. 4 depicts the *M*s and *SE*s of aesthetics and creativity for the control and the experimental groups.

The results showed that there were Group × Test interaction effects on improvement of creativity, $F(1, 73) = 4.781$, $p = .032$, $\eta_p^2 = .061$. Further simple main effect analyses for this interaction showed that both the control and the experimental group improved their creativity, $F(1, 39) = 6.021$, $p = .019$, $\eta_p^2 = .134$ and $F(1, 34) = 28.250$, $p = .000$, $\eta_p^2 = .454$, respectively. However, the results suggest that the experimental group had greater improvement than the control group in creativity after the training, $F(1, 73) = 6.495$, $p = .013$, $\eta_p^2 = .082$.

On the other hand, there were no Group × Test interactions, nor Group main effects on improvement of aesthetics, $F(1, 73) = 0.077$, $p = .782$, $\eta_p^2 = .001$; and $F(1, 73) = 2.476$, $p = .120$, $\eta_p^2 = .033$. However, there were significant Test effects, $F(1,$

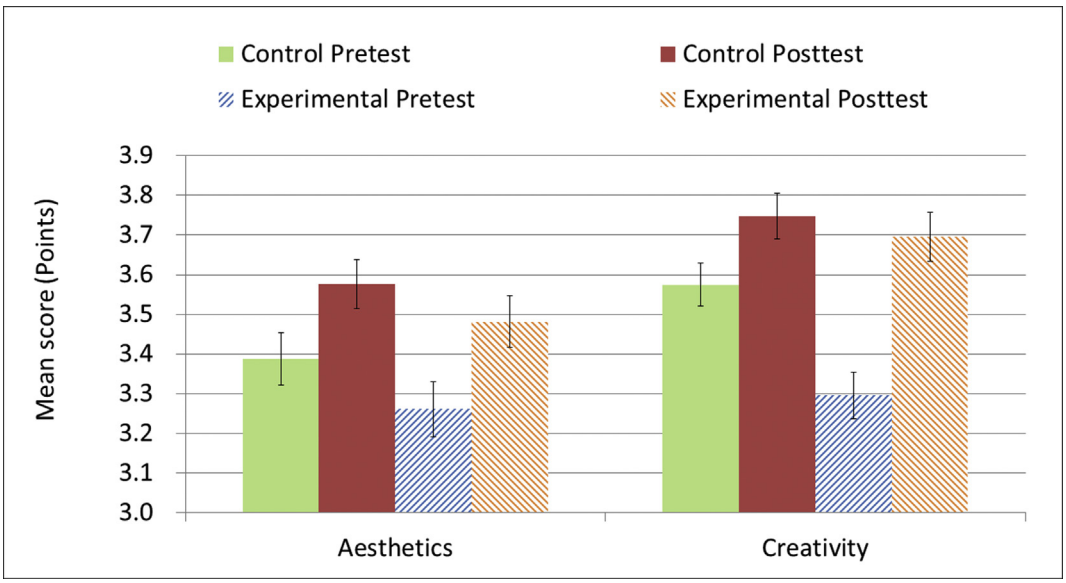

Fig. 4. The Ms and SEs of the participants' creativity and aesthetics scores on the design of a coffee shop.

Table 2
Results of group × aesthetic attention by Repeated measure ANOVA.

Source	ANOVA				
	MS	*F* (1, 74)	*p*	η_p^2	
Beauty of humanity					
Group	7.325	5.163*	.026	.065	b > a
Attention	10.097	24.136***	.000	.246	2 > 1
Group × Attention	.518	1.237	.270	.016	
Beauty of manifestation					
Group	.687	.702	.405	.009	
Attention	9.546	26.318***	.000	.262	2 > 1
Group × Attention	.652	1.796	.184	.024	
Beauty of space					
Group	2.739	2.281	.135	.030	
Attention	7.928	19.293***	.000	.207	2 > 1
Group × Attention	.033	.081	.777	.001	
Beauty of spirituality					
Group	4.978	2.633	.109	.034	
Attention	6.384	12.541**	.001	.145	2 > 1
Group × Attention	.594	1.167	.283	.016	
Beauty of transcendence					
Group	10.192	6.904*	.010	.085	b > a
Attention	8.492	16.746***	.000	.185	2 > 1
Group × Attention	.966	1.905	.172	.025	

Note. 1 = pretest; 2 = posttest. a = control group; b = experimental group.
*$p < .05$.
**$p < .01$.
***$p < .001$.

73) = 11.599, $p = .001$, $\eta_p^2 = .137$, suggesting both the control and the experimental group improved their aesthetic ability after the training.

4.2.2. Self-reflection of feedback effects by the experimental group

Two types of feedback (analyses for test items and peer evaluation of designed coffee shop) were employed to the experimental group. A 6-point Likert scale with four reflection questions was employed to examine the effects of the manipulated feedback (see Table 2). The results revealed that the participants in the experimental group were very positive about the influences of both types of feedback on their improvement of aesthetics and creativity in the coffee shop design (*Ms* = 4.80 to 4.97).

4.2.3. Group differences of attention to aesthetics when designing the coffee shop

To examine whether the manipulation of this study would lead to different degrees of attention on five facets of aesthetics (beauty of humanity, manifestation, space, spirituality, and transcendence), and further lead to different improvements in the coffee shop design, we employed several Group (Control vs. Experimental) × Aesthetic attention (first coffee shop design vs. second coffee shop design) Repeated Measure ANOVAs. The attention scores were based on 10 self-reflection questions regarding conscious thought devoted to each of the five aesthetic facets when designing the coffee shop. Humanity considers human needs, life quality, and cultural meaning; manifestation is related to style, form, and color; space refers to the arrangement of objects and space; spirituality involves visual perception, emotional arousal, and association; and transcendence indicates innovation, originality, and valuableness.

The results showed that there were significant Group effects on beauty of humanity as well as on beauty of transcendence. Comparisons of the means indicated that the experimental group outperformed the control group. Moreover, significant differences were found between the pretest and posttest scores on all of the aesthetic facets. All the attention scores in the second coffee shop design were higher than those in the second coffee shop design (see Table 3 and Fig. 5).

Table 3
Ms and SDs of the reflection questions.

Items	*M*	*SD*
1 The explanations for the test items in the training program contributed to my understanding of aesthetics.	4.86	.772
2 The explanations for the test items in the training program contributed to my understanding of creativity	4.89	.718
3 The explanations for the test items in the training program contributed to my creativity in the second coffee shop design.	4.80	.719
4 The peer evaluation for the first coffee shop design inspired my creative ideas in the second coffee shop design.	4.97	.747

Note. $N = 35$.

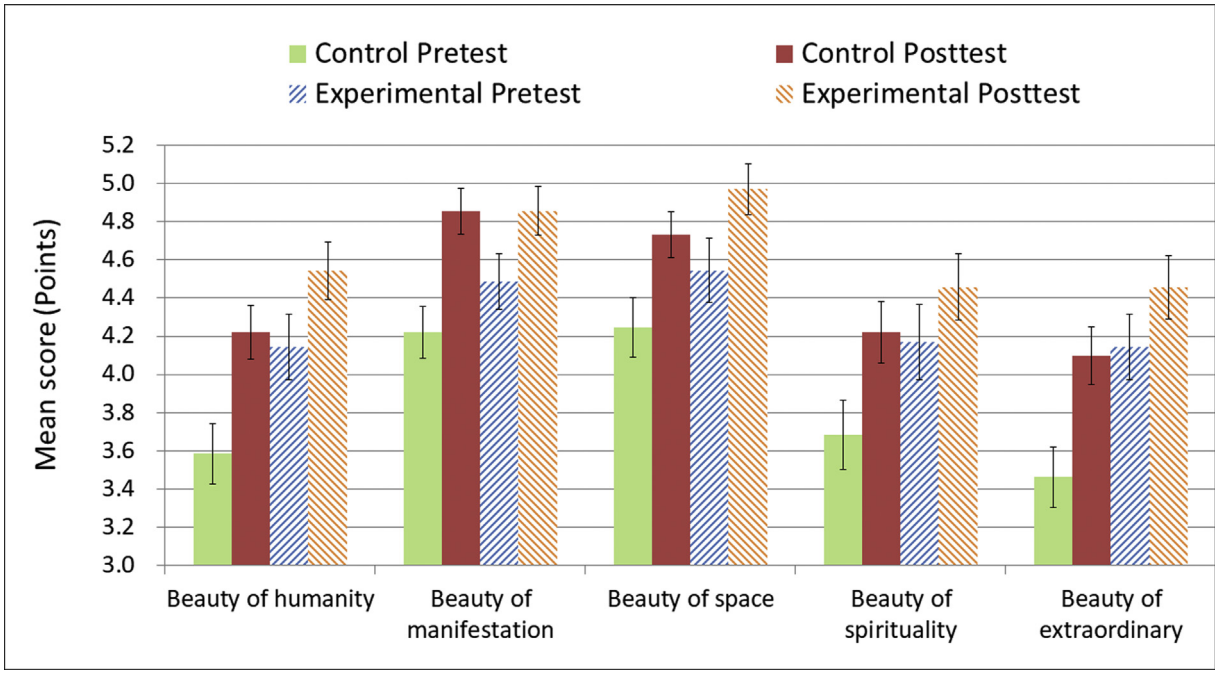

Fig. 5. Ms and SEs for different groups regarding attention towards aesthetics when designing the coffee shop in the pretest and the posttest.

4.2.4. Group differences in self-evaluation of the training effects on creativity performance

To examine whether a specific training content contributed to the improvement of creativity performance and whether there were group differences on these training contents, we conducted six one-way ANOVAs with Group (Control vs. Experimental) as the independent variable and each of the 6 self-reflection scores regarding how certain training content influenced creativity performance as the dependent variable. The *M*s and *SE*s for the concerned training contents and overall experience are displayed in Fig. 6.

The results showed a significant Group effect on all of the analyses and indicated that the experimental group outperformed the control group on all of the analyses. Specifically, for "color and association": $F(1, 74) = 9.167$, $p = .003$, $\eta_p^2 = .110$; for "color combination and harmony": $F(1, 74) = 7.981$, $p = .006$, $\eta_p^2 = .097$; for "picture and text composition", $F(1, 74) = 9.510$, $p = .003$, $\eta_p^2 = .114$; for "emotional expression and product design", $F(1, 74) = 7.617$, $p = .007$, $\eta_p^2 = .093$; for "creativity, aesthetics, and space design", $F(1, 74) = 5.056$, $p = .028$, $\eta_p^2 = .064$; and for "overall experience": $F(1, 74) = 6.101$, $p = .016$, $\eta_p^2 = .076$.

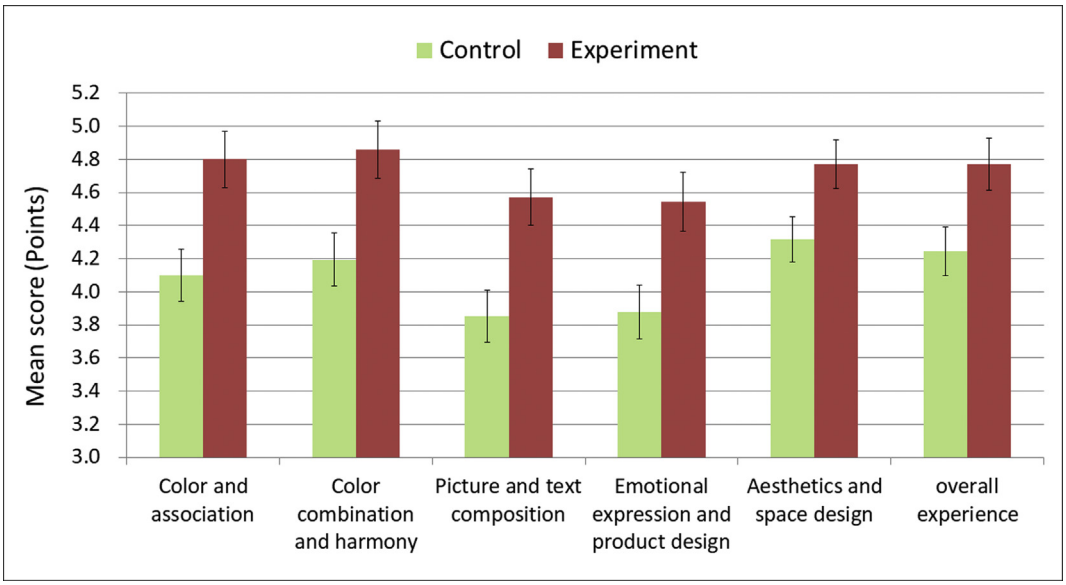

Fig. 6. The Ms and SEs of self-evaluated improvements of specific aesthetic contents for creativity performance in the Control and the Experimental group post aesthetic training intervention.

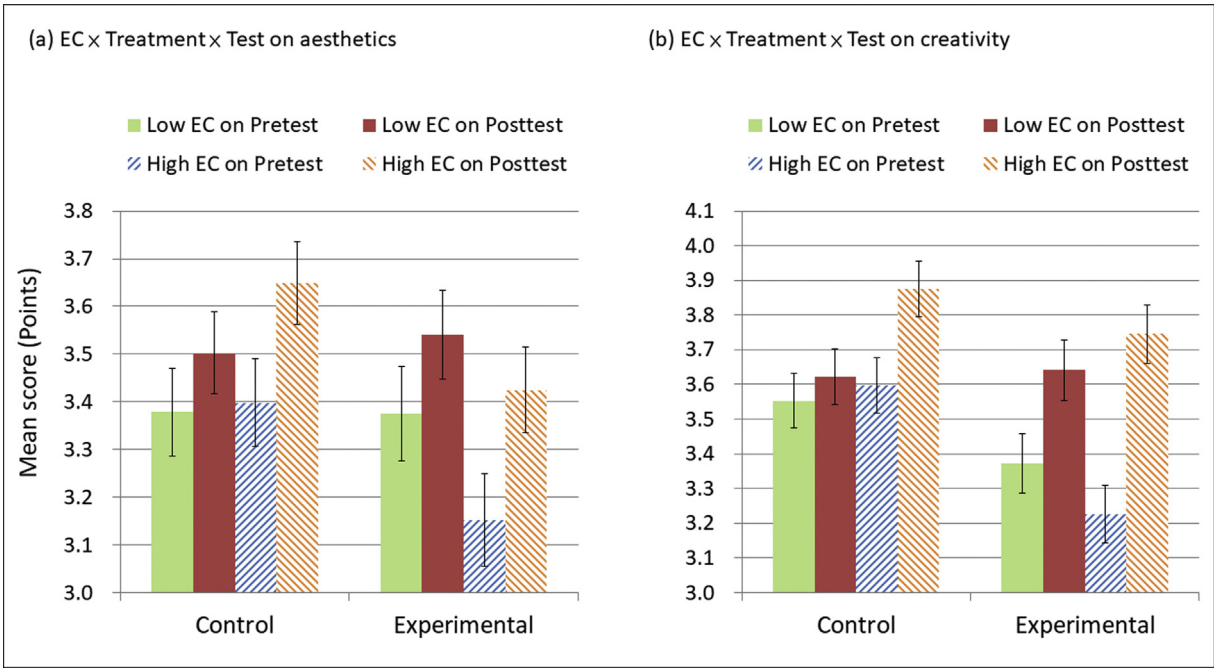

Fig. 7. Ms and SEs of aesthetics and creativity for the Low- and the High-score group of EC.

4.3. *Analysis of personal trait × treatment interaction effects*

Using Repeated Measure Analysis of ANOVA, we examined whether there were Personal trait (Low-score group vs. High-score group) × Treatment (Control group vs. Experimental group) interaction effects on the participants' improvements (Pretest vs. Posttest) in aesthetics and creativity. The personal trait variables included in this study were EC and DA. Each of the independent variables were split at the median into two groups (Low group vs. High group). Fig. 7 and Fig. 8 depict the *Ms* and *SEs* of aesthetics and creativity for the Low-score and the High-score group of the personal trait variables examined. The significant results are

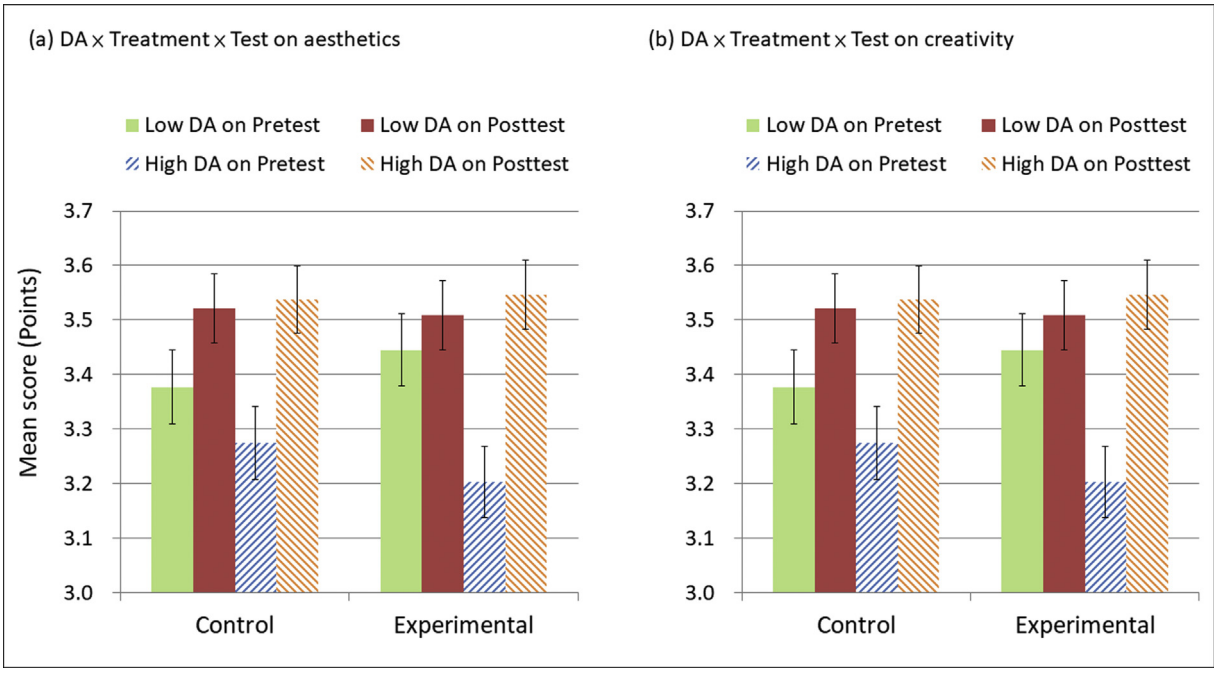

Fig. 8. Ms and SEs of aesthetics and creativity for the Low- and the High-score group of DA.

Table 4
Significant results of EC × treatment and DA × treatment on aesthetics and creativity by Repeated Measure ANOVA.

Source	ANOVA				Comparison
	MS	*F*	*P*	η_p^2	
EC on aesthetics					
Test	1.539	11.345***	.001	.138	2 > 1
EC on creativity					
Test	3.012	31.721***	.000	.309	2 > 1
Test × Treatment	.459	4.830*	.031	.064	C2 > C1; E2 > E1
Test × EC	.491	5.174*	.026	.068	L2 > L1; H2 > H1
Treatment	1.027	6.546*	.013	.084	E > C
DA on aesthetics					
Test	1.471	11.497***	.001	.139	2 > 1
Test × DA	.679	5.306*	.024	.070	H2 > H1
DA on creativity					
Test	2.930	31.906***	.000	.310	2 > 1
Test × Treatment	.491	5.344*	.024	.070	C2 > C1; E2 > E1
Test × DA	.690	7.510**	.008	.096	L2 > L1; H2 > H1
Treatment	.976	6.304*	.014	.082	E > C

Note. Test: 1 = pretest; 2 = posttest. E: experimental group; C: control group. L = low-score group; H = high-score group.
*$p < .05$.
**$p < .01$.
***$p < .001$.

displayed in Table 4.

Regarding the EC and Treatment interaction effect on the improvement of aesthetics, only the main effect of Test (pretest vs. posttest) was significant. Comparison of means indicated that participants performed better in the posttest than in the pretest. With regard to Test × Treatment effect, simple main effect analyses revealed that although both the control and the experimental group improved their creativity, the experimental group had greater improvement than the control group. In addition, the Test × EC interaction effect analyses revealed that both Low- and High-score groups of EC significantly improved their creativity, but the High-score group had greater improvement than the Low-score group. As for main effects, the Test and the Treatment effects were significant, suggesting that all participants improved their creativity after the training, but the experimental group had greater improvement than the control group (see Table 4).

Regarding the DA and Treatment interaction effect on the improvement of aesthetics, analysis of the Test (pretest vs. posttest) × DA effect revealed that while the Low-score group of DA did not significantly improve their aesthetics, the High-score group of DA did. In addition, the main effect of Test indicated that participants performed better in the posttest than in the pretest. As for Test × Treatment effect, both the Control and the Experimental group significantly improved their creativity; however, the experimental group had greater improvement than the control group. In addition, the Test × DA interaction effect analysis revealed that although both the High and Low-score groups of DA improved their creativity, the High-score group had greater improvement than the Low-score group. As for main effects, the Test and the Treatment effects were both significant, suggesting that all participants improved their creativity after the training, but the experimental group had greater improvement than the control group (see Table 4).

5. Discussion

5.1. FACE with constructive feedback can facilitate the improvement of aesthetics and creativity

This study endeavored to improve college students' creative ability through an aesthetics-integrated computer-based learning system that emphasized FACE (Feedback, Aesthetic experience, Creative design, and Evaluation). Moreover, this study sought to understand whether aesthetic desire and emotional creativity would carry personal trait-treatment interaction effects on the learning of creativity. To achieve the purposes of this study, six hypotheses were proposed and, except for H3 (EC would be a moderator of the learning of aesthetics during the training), all of the hypotheses were supported.

In supporting the necessity of integrating Arts into STEM education, as well as exploring alternative methods for enhancing creativity which diverges from the classical methods of solely employing divergent thinking tasks (Sagger et al., 2017), we developed an interdisciplinary computer program for creativity enhancement. The program was developed based on indices of good treatment fidelity (Borrelli et al., 2005; Capin et al., 2017). Specifically, our training integrated cognitive and affective components of aesthetic experience, with computer science, technology, and art. Notably, the FACE strategies were also employed in the training. Preliminary analysis of this study revealed that aesthetic ability and creativity were significantly correlated which demonstrated that aesthetics and creativity were closely related, and provided an important empirical basis for the design of our training program for further analyses of this study. According to Wiberg and Stolterman (2014), a novel human-computer interaction (HCI) design that facilitates systematic knowledge development should be evaluated by generic design thinking which includes the process of identification of

new ideas, exploration and elaboration, design implementation, and evaluation. In this study, we first identified the lack of emphasis on both originality and valuableness in game-based creativity training. Then, we explored the possibility of using an interdisciplinary approach by integrating aesthetic experience and 3D-design into game-based creativity training, by which, we developed the FACE approach. After that, we implemented the design through an experimental instruction. Finally, we examined and verified the effectiveness of the FACE approach of creativity training as well as the moderation effects of DA and EC during the training. Therefore, our study can be regarded as a novel HCI design in research and instruction of creativity.

In this study, two types of constructive feedback (expert interpretations for aesthetic judgment and idea sharing from peer-evaluation of the designed product) were employed in the experimental condition in addition to FACE learning. We assumed that after the training, both the control and experimental groups would improve their creative ability, with the experimental group exhibiting greater improvements for the extra constructive feedback they received. The results of repeated measures of ANOVA support our assumptions. To verify the training effects, we also employed reflection questionnaires. The results showed that the participants in the experimental group were very positive about the influences of both types of feedback on their improvement of aesthetics and creativity in the coffee shop design. Moreover, all the participants reflected a stronger degree of attention to the five facets of aesthetics (beauty of humanity, manifestation, space, spirituality, and transcendence) after the training, but the experimental group exhibited a stronger degree of attention for the beauty of humanity and beauty of the transcendence than the control group. Furthermore, repeated measure ANOVA analyses of the self-evaluating reflection responses indicated that the experimental group reported significantly higher levels of improvement than the control group in aesthetic and creative ability with their second coffee shop design, as well as on the aesthetic training intervention. These findings suggest that the FACE training, especially the experimental condition that provides constructive feedback, is capable of improving college students' aesthetic and creative ability. These positive findings support that enhanced knowledge within the context of the created product can facilitate creativity (Chad-Friedman et al., 2018), as well as illustrate the salience of positive feedback on creativity performance and supports the body of research suggesting that constructive feedback and positive affect can facilitate creativity performance (e.g., Chad-Friedman et al., 2018; Gong & Zhang, 2017; Hennessey & Amabile, 2010; Yeh et al., 2016).

A major treatment in this study is constructive feedback. Fink et al.'s (2010) study yielded positive results and participants who were exposed to the ideas of others improved their creativity. This type of creative inspiration and idea generation technique was also utilized in the present study. The experimental group in our design was given the opportunity to view and score the coffee shop designs of their peers. The significant improvement of creativity supports our hypothesis that appreciating or critiquing many other coffee shop designs would likely result in the generation of new ideas, and improve aesthetics and creativity. In addition, one facet of the creativity training employed in this experiment was a 3-D design program where participants created their own coffee shop, and practiced the concepts they acquired during the intervention. The positive findings of this study suggest that 3-D design software can act as an efficient vehicle for a practical application of knowledge gained in aesthetics-integrated training for creativity. These results support the conclusions of Saorín et al. (2017) who found that 3-D designing improved creativity in engineering students. The 3-D design program in our study allowed participants to explore the use of a computer program for creativity enhancement, and offered hands-on experience implementing the aesthetic concepts acquired through the intervention training. This educational technique is maker-centered learning that utilizes a variety of tools and technologies to facilitate inspiration and interest for interdisciplinary learning; it has been suggested to be an effective method for teaching STEM (Science, Technology, Engineering, and Math) (Clapp & Jimenez, 2016).

After the aesthetic training, both conditions improved in aesthetic ability with the experimental condition outperforming the control, however the differences were not statistically significant. Aesthetic experience involves complicated cognitive processes, such as perceiving, understanding, valuing, and developing opinions about art; although aesthetic proficiency can be improved with training (Hung & Young, 2017; Locher et al., 2001; Millis, 2001; Nodine, Locher, & Krupinski, 1993; Sagger et al., 2017; Silvia, 2005, 2006), sufficient duration of the instructional period may be necessary in order to cultivate the ability and observe significant improvements.

To conclude, aesthetics can be a vehicle for creativity enhancement and furthermore, FACE interventions provide some additional benefits to participants, including enhanced aesthetic understanding and aesthetic ability. Previous studies evaluating creativity enhancement (e.g., Fink et al., 2010; Scott et al., 2004; Sun et al., 2016; Valgeirsdottir & Onarheim, 2017; Wei et al., 2014) have not employed aesthetic training directly, and our experiment sheds light on the possibility of using aesthetics in creativity cultivation. Aesthetic training as a means for creativity enhancement has many potential benefits. Furthermore, the superior performance of the experimental group illustrates the effects of bringing learning to the conscious level with constructive feedback.

5.2. Desire for aesthetics and emotional creativity are moderators in FACE learning

Based on the four P's theory of creativity (Valgeirsdottir & Onarheim, 2017) and Componential Theory of Creativity (Amabile, 1996), personality and motivation are critical factors for creativity performance. In this study, two personal traits—EC and DA—were included to examine how personal traits may interact with treatments of the instruction during the training. The findings suggest that both EC and DA are important moderators for the learning of creativity during the aesthetics-integrated training; those who had a higher degree of EC and DA, had greater improvement in creativity after the training. These empirical findings suggest that emotions play a large role in creativity and cognition, which is in line with findings in past behavioral studies (e.g., Yeh et al., 2016; Yeh, 2017) and neuroscientific studies (e.g., Ashby et al., 2002; Yeh, 2017). Individuals who poses high levels of EC may experience elevated emotional arousal, which would then cause the release of neurotransmitters noradrenalin and dopamine, and stimulate the cognitive processes involved in creativity, such as emotional regulation, planning, efficiency of working memory, and original ideas (Ashby

et al., 2002; Floresco & Phillips, 2001).

Additionally, the findings of this study suggest that DA, a type of intrinsic motivation in learning aesthetics (Lundy et al., 2010), may facilitate aesthetic understanding and awareness of beauty, make aesthetic experience more enjoyable, and provoke autonomous learning (Locher et al., 2001; Silvia, 2006). This trait may subsequently encourage positive aesthetic emotion and enhance the understanding of aesthetics, which further, improve creativity performance in product design. It has been suggested that through motivation and working memory capacity, positive emotion promotes cognitive flexibility and inclusiveness in creative performance (De Dreu et al., 2008).

Moreover, creative thinking processes involve both bottom-up and top-down cognitive control, as well as unconscious and conscious processes through the use of semantic integration, memory retrieval, and attention (Fink et al., 2010). The findings of this study suggest that EC and DA may interact with the FACE intervention provided in the training, and then influence creativity performance through both the conscious and unconscious processes. These results also support the importance of constructive feedback during creativity training, which is in line with previous research (Fink et al., 2010; Gong & Zhang, 2017) suggesting that supportive supervisor feedback that induces positive affect indirectly promotes creativity.

6. Conclusions

The field of education is exploring new methods for appropriating computers, or other technological devices for the delivery of creativity instruction. To date, the majority of creativity enhancement research has focused on training creative skills of originality assessed by divergent thinking tests. This study contributes to the development of a new-paradigm for creativity enhancement through an aesthetics-integrated computer-based training that emphasizes FACE and interdisciplinary learning. Notably, the creativity skills of producing original ideas and assessing value are both included in the training, and creativity performance is assessed by 3-D product design.

The results of this study suggest that the FACE training program can enhance college students' aesthetic ability and creativity through both the unconscious and conscious processes, although additional emphases on conscious learning contributes to better improvement; EC and DA may act as moderators during the training. The findings also suggest that facilitating attention through immediate constructive feedback on learning tasks and creative design can be an effective way to increase conscious learning and creativity during computer-based learning.

With great treatment fidelity, this study provides empirical evidence for the valuableness of including Art in STEM education. Moreover, the findings shed light on the dynamic interactions between design, aesthetics, and creativity, and suggest that instruction of creativity can be achieved through the cultivation of aesthetic cognition and ability. Moreover, cultivating the personal traits of EC and DA may facilitate the effects of implementing aesthetics and technology into a computer-based training for creativity.

7. Limitations, suggestions, and educational implications

The product creativity employed in this study pertains to the common, everyday type of creativity which is often evaluated through consensual assessment (Hennessey & Amabile, 2010). This study utilized the consensus of peer evaluation, instead of expert scoring, to measure the participants' aesthetics and creativity. In addition, aesthetics are, in a part, subjective. Although expert rating may be more reliable in terms of consistency with theories of aesthetics, consensus of peer rating provides understanding for objective beauty and creativity among college students. Future studies can compare the consistency between experts and novices rating in aesthetics and creativity.

In addition, this study employed a one-time training program. Although the experiment in this study lasted for about 4.5 h and there were significant training effects, the results need to be replicated in a training program that is distributed over many sessions of adequate duration to examine its retention effects. Future studies or classroom instructions can also compare the learning effects of one-time training versus multi-session training. Furthermore, the 3-D design program may have limited participants' aesthetic and creative expression because the program offered limited options for their coffee shop. Further studies can try to offer more dynamic options to maximize the learning effect.

Within the field of education, there is a recent trend of utilizing maker-centered learning, (Clapp & Jimenez, 2016). Maker-centered learning has increased in popularity, and advocates of the movement boast its effectiveness in teaching STEM. With these new methods for inspiring creativity with hands-on learning, and incorporating aesthetics into other curricular domains, it appears that the evolution of education demands new and innovative techniques for arts integration. Our experiment offers an original and cutting-edge synthesis of creativity enhancement through aesthetic training that could offer interdisciplinary benefits to the scientific or technological agenda. Due to time limits in this experiment, we only included the 3-D coffee-shop design in the training program. Future studies can include more maker-centered learning activities in a computer learning program or in real classroom teaching to amplify the training effects, as well as enhance the retention of creativity improvement.

Finally, the FACE computer-based design intervention employed in our study encompasses major characteristics of effective training, such as specific cognitive activities and challenging tasks that connect to the real-world, domain specific practice, and heuristic exercises. Within the 95-min computer-based training course, the participants' creative and aesthetic abilities improved. Training such as this can easily be adapted for practical classroom teaching with only a couple of sessions needed for creativity enhancement. Through the FACE approach with constructive feedback, the mind will be given the opportunity to invent, inspire, and create.

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Appendix A

Table A
Factor loadings of the Desire for Aesthetics Scale

Original item number		Factor loading			
		1	2	3	4
Factor 1: Music					
14	Some of my best experiences in life have occurred because of listening to amazing songs.	.794			
10	Hearing gorgeous songs is a major motivator for me in daily life.	.751			
5	I have a good idea about what my favorite albums/cd's are of all-time.	.693			
6	I am constantly searching for new, beautiful music to care about.	.627			
Factor 2: Art and architecture					
4	I could stare a long time at a beautiful painting.		.805		
3	I often find myself staring in awe at beautiful things.		.638		
15	I really enjoy creating beautiful things in one or more artistic areas such as visual art, music, writing, etc.		.622		
1	In the past, when I've moved into a new apartment, office or dorm, one of the first things I do is decorate the walls with nice artwork.		.570		
2	I have a strong appreciation for great architecture		.569		
16	I tend to notice and care about the color of the walls in a room.		.520		
Factor 3: Appearance and attraction					
12	I find beautiful faces very memorable			.847	
8	Very good-looking people often turn my head.			.797	
13	The first time I meet somebody, I tend to notice very readily how nice his or her clothes look.			.460	
Factor 4: Cognition and emotion					
7	My moods are affected by the attractiveness of my surroundings.				.815
9	When at a restaurant or nightclub, I am not affected very much by the attractiveness of the décor.				.731
11	I care a great deal about beauty in many areas of everyday life.				.519

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