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RESEARCH ARTICLE

Factors affecting creativity in the architectural education process based on computer-aided design

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Abstract
One of the most influential factors in architectural design is creativity. The enhancement of student creativity is a universally sought objective. This research hypothesized that computer-aided design, experience, sketching, physical modeling, learning environment, and images and visual references can serve as powerful tools to stimulate creativity in the architectural design process. It sought to investigate which of these components has the greatest impact on increasing student creativity. A total of 114 bachelor students and 347 master students of Architecture were surveyed using a questionnaire. Data were then analyzed using SPSS and one sample *t*-test and Friedman test for ranking. Results showed that experience can significantly increase the creativity of students in the architectural design process compared to the other components.

1. Introduction

In recent decades, many developments have been achieved in the field of architectural design, and numerous academies have contributed to the creative design and variety of design procedures. Several design process theories have also been proposed during the same period (Alexander, 1979; Darke, 1979). In a publication on design methodology, Sydney Gregory (1966) argued that every design problem can be approached from infinite angles. Likewise, Broadbent (1973) stated that a design problem can be approached seven general ways (Davey, 2008: 4). However, Dorst and Cross (2001) suggested that creativity remains one of the fundamental factors in the architectural design process. In the middle decades of the 20th century, many studies on the effect of creativity on architectural design and its associated factors have been conducted (Cross, 1997; Howard et al., 2008; Dorst, 2011; Bashier, 2014; Tzonis, 2014; Baghaei Daemei et al. 2017).

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The factors that may influence student creativity (Crilly and Cardoso, 2017; Lu, 2016; Augello Infantino et al., 2015; Cybulski et al., 2015; Chang, 2013; Casakin and Kreitler, 2010; Kowaltowski et al., 2010; Christiaans and Venselaar, 2005) can be divided into several general categories, including group activities (Farhang et al., 2008; Eslami et al., 2009; Hoegl and Parboteeah, 2007), learning environment (Azemati et al., 2016; Karimi Azeri et al., 2015a; Nazidizaji et al., 2015a, 2015b, 2015c; Amabile and Conti, 1999; Cho, 2017), teachers (Chambers, 1973), technology (Bertol, 1997; Snyder, 1998; John, 2015; Robertson and Radcliffe, 2009; Kazanjian et al., 2000; Lawson, 1999; Kalay, 2006: 376; Mozaffar and Khakzand, 2009), and sketch images and visual references (Khakzand, 2009; Tian, Masry et al., 2009; Yavuz and Yildirim, 2012).

Other researchers also cited the systematic approach named TRIZ as one of the factors that boost creativity (Chang et al., 2016; Pokhrel et al., 2015; Nazidizaji et al., 2015a, 2015b, 2015c; Li et al., 2007; Ogot and Okudan, 2006; Totobesola-Barbier, Marouzé et al., 2002; Low et al., 2000). Factors associated with creativity are generally outlined in research literature, and thus, determining which factors play an effective role in boosting student creativity in architectural design is important. The purpose of the present study is to assess the six factors that affect the creativity of students, including computer-aided design (CAD), experience, sketch, images and visual reference, learning environment, and physical modeling. Ranking these components will show which of them has the greatest impact on the creativity of architecture students. CAD is also associated with the extent of architectural creativity among students.

2. Theoretical framework

2.1. Architectural design process

Creativity is the cornerstone of architecture (Danaci, 2015). It is one of the captivating and stimulating aspects of the human mind and is defined as the ability to change old ideas to produce unique inventions (Heap, 1989). According to (Mozaffar and Khakzand, 2009), the design process has two main features: first, it is an essentially creative effort, and second, it is closely associated with drawing. Christopher Alexander believes that the design process consists of two primary stages, namely, analysis and synthesis (Laseau, 1980). Lawson believes that the creative process has five stages, namely, first insight, preparation, incubation, illumination, and verification (Schon and Wiggins, 1992). In Jones' model, the relationship between the three stages of analysis, synthesis, and evaluation is defined within a circular diagram that represents the evolution of a raw and abstract idea to a decision and, ultimately, to a final solid idea (Gross, 1996). Meyer describes the design process as a problem-solving process in which creativity plays a central role. The process proposed by Meyer consists of four stages: preparation, incubation, illumination, and proof/negation.

Rzevsti characterizes the design process as an investigative, creative, rational, and decision-oriented procedure (Laseau, 1980). Goel describes the design process in stages of initial design, refinement (improvement), and detailed design. According to Riba (1973), the design process includes the three stages of analysis, synthesis, and evaluation.

Another approach is the intellectual-ideological approach to the design process, which refers to the procedure designers use to deal with any design problem. These approaches to the design process can be divided into three groups, namely, logical rational model, creative intuitive model, and participation collective model. Archer (1969) proposed eight stages for the design process as follows: briefing, programing, data collection, analysis, synthesis, development, communication, and solution. Table 1 shows the details of the design process from the view of other researchers.

The architectural design process can be described as the procedure of drawing ideas from one's unconsciousness. It originates, as an abstract idea, from the thought and experience of a person and gradually develops into a tangible novel subject through a process of conversion of subjectivity to objectivity, which is mediated by creativity (Fig. 1).

Fig. 1 shows the process through which a designer creates an architectural space. As can be seen, creativity is one of the primary requirements for the creation of architectural space. This study aims to investigate the factors associated with this particular feature.

2.2. Aspects of creativity

Louis Sullivan stated that imagination and creativity are innate, not learned, but they seem to be inherent talents that can also be acquired and reinforced with appropriate training (Antoniades, 1990). Einstein stated, "Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution" (Russo and Montecchi, 2011). According to Antoniades (1990), imagination is a catalyst for visualization, and visualization serves as a filter through which imagination must pass before achieving realization. Guilford (1968) provided an alternative definition, stating that creativity is the novel product of the useful and beneficial work of an individual or a group (Stein, 1974).

Therefore, creativity is a combination of several functions, including innovation, flexibility, and sensitivity to other views. It enables the learner to transcend irrational thinking and reach new heights of productivity and satisfaction. Runco noted that creativity is a convenient yet powerful tool to solve problems through innovative solutions. Robins believed that creativity involves identifying new qualities in old concepts, meanings and ideas, or coming up with new ways of organization.

Chen et al. (2012) suggested that designer problems in producing creative conceptual designs often stem from the lack of sufficient multi-disciplinary knowledge. A research by Loxton (1969) on design education in schools concluded that "experience" is one of the most important factors in the creative process (Lawson, 2013). In a publication by Gordon (1961) on creativity empowerment, he characterized creativity using four analogies, namely, symbolic,