An Educational model of Creativity Enhancement in Design Studios Using Prior Researches

Behnam Kalantari [a], Abdolmajid Nourtaghani [*,b], Mohammad Farrokhzad [b]

[a] *Department of Architecture, Sari Branch, Islamic Azad University, Sari, Iran*

[b] *Department of Architecture, faculty of engineering, Golestan University, Gorgan, Iran*

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Abstract

Despite a large body of research on creativity in architecture, the concept of creativity as a multi-faceted phenomenon in design studios is still challenging. The present study aims to analyze the related literature and systematically categorize them to provide a conceptual framework to enhance creativity in design studios. By using a qualitative researcher method along with Sandelowski and Barroso's seven-step meta-synthesis model, the researchers attempted to conduct a systematic study on the previous literature. 579 articles published between 1999 and 2020 were selected by the relevant keywords dealing with aspects of creativity and its role in design studios. Having reviewed the titles and abstracts of these articles, around 60 papers were selected for the final review. The results suggested that the conceptual elements of creativity, including person, environment, process, and product, are very significant in creativity enhancement in design studios but these factors alone cannot promote students' creativity. Therefore, other factors, such as instructional interventions in teaching creativity with the aid of creativity support tools, as well as a continuous assessment of creativity during the creative process, can be very helpful in promoting creativity. Consequently, it was found that the creativity enhancement elements in design studios can be classified into three main categories: conceptual framework, interventions, and assessment.

Keywords: Creativity, Architecture, Enhancement, Education, Design Studio

1. Introduction

Despite a vast number of studies done on it, there is still confusion regarding the precise definition of creativity. Studies have suggested that creativity and innovation prepare the ground for the fulfillment, as well as personal, professional, and social success, particularly in the building industry and in architectural education (Sarakar & Chakrabarti, 2007; Turnbull, Littlejohn, & Allan, 2010; Kilicaslan & Efe Ziyrek, 2012).

In recent years, encouraging creativity has received considerable attention (Turnbull et al., 2010; Yan, Jiang, Squires, & Childs, 2014). For example, in China, South Korea, and the United States, creativity has been intensively encouraged, as politicians and educators are united around the idea that students' creativity must be encouraged and enhanced. (Sawyer, 2017). Therefore, it seems necessary to scrutinize the way creativity can be promoted in students.

Creativity and its constituent parts have been systematically reviewed and explored in various fields. The research was conducted on topics such as the role of the creative learning environments in education, teachers' beliefs about creativity, teaching creativity in art and design studio classes, the role of teachers in creativity enhancement, and theoretical perspectives on creativity and cooperative learning (Hamalaninern & Vahasantan, 2011; Davies et al., 2013; Sawyer, 2017; Bereczki & Karpati, 2018). Most of these studies have shown that the dominant factors affecting creativity are process, product, person, and environment (Thompson & Lordan, 1999; Lewis, 2005; Richard & Catherine, 2006; Howard, Culley, & Dekoninck, 2007; Casakin & Kreitler, 2008; Turnbull et al., 2010; Williams, Ostwald, & Askland, 2011; Demirkan & Afacan, 2012; Kremer,2019; Mahmoud et al., 2019; Aderonmu et al., 2016).

Further review of the literature revealed that interventions can play a significant role in enhancing creativity. For instance, role-playing, teaching art, group work, change in teaching methods, teaching creative forms, music, observation, sketching, 3D software, puzzles, contextual learning, cooperative learning, inhomogeneous groups, and adapting and modifying lessons to better match the creative concept are reflected in these types of research. (Mellou,1994; Russ,2003; Garaigordobil,2006; Hargrove,2012; Hassanain, Alhaji Mohammed, & Cetin, 2012; Alfonso, Meléndez, & García-Ballesteros,2013; Abbasi & Tucker, 2015).

There are more than 250 tools that promote and support creativity and innovation in design and production in different countries and different disciplines such as industry, education, and science (Thompson & Lordan, 1999; Pahl, Newnes, & McMahon, 2007; Kowaltowski, Bianchi, & De Paiva., 2009; Chulvi, Sonseca, Mulet, & Chakrabarti, 2012; Yan et al., 2014). However, only a few of these tools have been used in design studios.

On the other hand, the results of these studies led us to another important factor in creativity: assessment, which is one of the significant issues in architectural education. Further examination of the literature revealed that creativity assessment is also of great importance in promoting creativity throughout the creative process. (Casakin & Kreitler,2006; Williams et al. 2010; Demirkan

* Corresponding Author Email: a.nourtaghani@gu.ac.ir

& Afacan,2012; Chiu & Salustri, 2010; Casakin et al.,2019; Koronis et al.,2018; Xiong et al.,2019).

The lack of integrated analysis of creativity, creativity enhancement techniques, and factors affecting it, was reflected in the studied literature. Therefore, this research aims to systematically review the previous literature using a well-designed methodology to present different theoretical and educational perspectives and the appropriate methods that can be used to enhance creativity in design studios. It also provides an appropriate conceptual framework to address the research gap, which is a requirement in architectural education. The following questions can help to achieve this goal:

1. What are the conceptual elements of creativity enhancement in design studios?
2. What is the evidence for intervention in creativity enhancement in design studios?
3. What is the evidence for assessing creativity enhancement in architecture studios?

2. Research Method

A growing number of studies done on various scientific areas have led to a systematic combination of past studies to reach a better understanding (Naghizadeh, Elahi, Manteghi, & Ghazinoory, 2015, p.31). This research is a qualitative meta-synthesis of published research reports. This helps collate and synthesize qualitative research in a comprehensive and methodologically rigorous way to attain deeper knowledge about the subject area.

Over the past decades, great effort has been made to develop, design, and implement meta-synthesis research. Noblit and Hare proposed three main phases for meta-synthesis research: selecting, synthesizing, and expressing the synthesis (as cited in Kamali, 2017, p. 728). In the same way, Sandelowski and Barroso introduced a seven-step method (Naseri, Noruzi, Fahimnia, & Manian, 2017, p. 288). We conducted the meta-synthesis based on the stages developed by Sandelowski and Barroso. These stages are demonstrated in Figure 1.

Fig 1. Sandelowski and Barroso's meta-synthesis steps

Step One: Setting Research Questions

The research questions are presented in the introduction.

Step Two: Conducting a Systematic Review of Literature

466 English articles published between 1999 and 2017, were selected from the available resources in Google Scholar. They include all the relevant keywords such as creativity, architecture, enhancement, education, design studios. In the same way, 113 Persian articles including two pairs of keywords of creativity, education and creativity, and architecture were downloaded from the Iranian Scientific Information Database (SID).

Step Three: Searching and Selecting Appropriate Studies

Having reviewed the 579 selected articles, the ones that did not fit the research questions were excluded. Titles and abstracts of these remained articles were screened. In total, 60 papers, including 54 English language literature and 6 Persian language papers, were selected for the final review. CASP (Critical Appraisal Skills Program) was used in the process of critically appraising and screening the articles.

Step Four: Information Extraction

The content analysis method was applied to analyze the selected materials. Content analysis is a research technique drawing replicable and valid inferences by interpreting and coding textual material. Qualitative data can be converted into quantitative data by systematically evaluating texts (e.g., documents, oral communication, and graphics). (Naseri et al., 2017, p. 295). We were required to be sufficiently precise to reach the goal of the meta-synthesis method, which relies on the systematic combination and interpretation of the results from multiple studies. To this aim, the relevant data were extracted from the articles. Each article was printed on paper. Then, the keywords and related content were recorded. According to the research questions, the relevant data were extracted from each of these 55 papers.
Reviewing 16 studies related to the first research question (What are the conceptual elements of creativity enhancement in design studios?) suggested that factors such as a person, process, product, and environment play a vital role in creativity enhancement. Creative people have several characteristics as listed below: verbal validity, higher intelligence, and motivation, flexibility, risk-taking, authenticity, tendency to identify problems and confidence, and achieve a creative product in a place that is a significant part of the creative process in an appropriate place (Casakin & Kreitler, 2008). Aderonmu et al. (2019) studied 225 architecture students from three selected schools of architecture in Southwest Nigeria. They suggest that the students' personality characteristics and didactic roles of architectural educators can nurture and cultivate architecture students' creativity.
Williams et al. (2011) highlighted the particular characteristics of creativity. Briefly, studies of the creative *person* lay stress on personal qualities and personality variables such as intelligence, values, temperament, personal attributes, physique, habits, defense mechanisms, self-concept, intrinsic motivations, knowledge, expertise, and skills. Studies of the creative *product* emphasize variables that relate to the outcome of the creative process. Craft compiled a list of the typical characteristics of creative individuals: "Openness to experience; independence; self-confidence; willingness to take risks; a sense of humor or playfulness; enjoying experiment; sensitivity; lack of feeling threatened; personal courage; unconventionality; flexibility; preference for complexity; goal orientation; internal control; originality; self-reliance and persistence" (cited in Pahl et al., 2007, p. 10).
Most design education, especially architectural design, takes place in a studio system, and the way students get stimulated in their design efforts is closely connected with the applied pedagogy, the instructors, and their ways of approaching design. Six main teaching methods can be applied in the studio setting (Kowaltowski, et al., 2006, p. 3):
1. Studio teaching according to given architectural program and site for a specific design project or architectural typology.
2. Studio teaching according to an architectural program, formulated by students and its appropriate urban setting.
3. Introducing the studio as a place for an actual design problem, developing a cooperative process, analyzing the problem, and providing solutions by students.
4. Teaching design in the form of a combination of architectural theory with practical design activities.
5. Teaching design making use of ''form generation'' methods and technical architectural language.
6. Teaching design to examine specific CAD design tools.

Hojjat (2004), described the objectives of the composition course as follow:
1. Arousing interest
2. Familiarization
3. Talent discovery
4. Self-knowledge
5. Skill development
6. Creativity enhancement.
He emphasized dynamic education, pioneering education, conscious education, clinical education, and conceptual learning. There is ample literature on creativity and how to enhance this thought process or ability (Kowaltowski et al., 2009, p. 456) on (Siqueira,2007; Runco, 2007; Boden 1999; Cross, 1997).. There is a wide range of research on the creative process and different types of it. For instance, Sielis, Tzanavari, and Papadopoulos (2009) cited Shneiderman's eight activities that support the creative process: search, consult, visualize, think, explore, compose, review, and disseminate (p. 426).
Kowaltowski et al. (2009) cited Kneller's four essential stages in a creative process, such as preparation, incubation, illumination, and verification (p. 458). Mahdavinejad (2005) added one stage (insight) to Graham Wallas's four-stage model of the creative process: Insight, Preparation, Incubation, Illumination, and Verification.
According to Dorst and Cross, (2001), creativity in the design process often features a significant event—the so-called 'creative leap'— that sometimes occurs as a sudden insight instantly recognized by the designer (p. 425). In their article, Clinton and Hokanson (2012) examined ways to gain benefits from an emphasis on creativity to enhance the design and development process and suggested directions for future research. They distinguished between the role of conceptual models of systems and the user's mental models. "As teachers, we have to develop conceptual models that will aid the learner to develop adequate and appropriate mental models" (p. 14).
Hasirci and Demirkan, (2007) explored the creative process and cited the five stages (5R's) of the Sensational Thinking model of O'Neill and Shallcross as a naturally occurring dynamic system within the creative process which includes: readiness, acceptance, reflection, revelation, and recreation.
Mahmoud et al. (2020) conducted a qualitative study on the relationship between tolerance of ambiguity of architectural students and their creativity. They concluded that tolerance of ambiguity is a personality trait that has been linked to creative thinking. The architecture students were subjected to the Torrance Test of Creative Thinking (TTCT). The analysis revealed that there is a significant

correlation between students' creativity, measured by TTCT.

These certain attributes of creativity define a creative design product: "Novelty (new, novel, unusual, unconventional, unique, original, infrequent, extraordinary, different, eccentric and exciting), elaboration (integrated, polished, refined, adequate, deliberate, detailed, sensible, balanced and coherent) and affective aspects (appealed, delighted, good and pleasant)" (Demirkan & Afacan, 2012, p. 265).

Williams (2011) emphasizes on the variables related to the creative product results (Idea and product).

Davies et al. (2013) cited evidence from a two-year study conducted on 211 children in Paris and its suburbs by Besancon and Lubart in 2008. They concluded that the overall environment and learning environment of a school account for variance in the creative performance scores of these children. According to Kremer (2019), creativity is a result of the interaction of a system composed of three elements: environment, process, and person. It has been proven that to express their creativeness and generate new ideas, individuals should have an appropriate environment.

Analyzing 26 papers related to the second research question (2. What is the evidence for intervention in creativity enhancement in design studios?) showed that factors such as background knowledge, instructional interventions, using creativity techniques, and creativity support tools are highly effective in architecture studios. Moreover, it was found that instructional interventions can enhance creativity. In their study, Sielis et al. (2009) asserted that the creative process could be improved by adding context-awareness in creativity support tools. They concluded context-awareness could be added in creativity support tools to tap the creativity process. Casakin et al. (2019) researched a sample of 171 student between the ages of 18 and 25. They concluded that educational programs aimed at promoting design creativity in design studios might find it helpful to use examples as a pedagogical tool to enhance design creativity.

Sobhiyah, Bemanian, and Keshtiban (2008) studied the role of improving creativity by suitable methods of knowledge and experiments transfer. They proposed three models to utilize educational experiences to design courses in architecture that can enhance design creativity (Individual Interaction Model – Class-Team Interaction Model - Teacher and Senior Student Interaction). Analysis of the collected data suggested the Interaction of Teacher and Senior Students as the best method in the view of the students who participated in the study. It was also proposed as a method of atelier management.

Hargrove (2012) stated that metacognition plays a prominent role in successful problem-solving. He studied metacognitive activities and developments to figure out how students can be taught to control their cognitive resources better. Jausovec carried out a group of studies to examine the effect of metacognition on problem-solving performance. When confronted with situations that cannot be solved by learned responses, metacognitive behavior enters. Metacognitive skills play an important role in case habitual responses are not helpful. (As cited in Hargrove, 2012, p. 10). Pir Khaefi, Borjali, Delavar, and Eskandari (2009) explored the impact of creativity on metacognitive components of creative thinking among 85 undergraduate Industrial-organizational psychology students of Islamic Azad University of Garmsar. Findings showed that the creativity training course improves the level of metacognitive elements of creativity in these students as there was a significant difference between the results of the control group and the experimental group. It was also revealed that a well-designed program brings about a positive change in the metacognitive components of creativity.

Boroon, Heidarie, Bakhtiar Poor, and Boroon (2013) probed the role of creative problem-solving training among third-grade middle school students in Ahwaz. They concluded that implementing pre-designed creativity training programs leads to positive changes in metacognitive elements (fluency, flexibility, and originality). Moradi and Norozi (2016) compared the effectiveness of computer-based educational games and traditional approaches to critical thinking skills and creativity of students of Tizhoushan Highschool in Tehran. The findings of this study confirmed the research hypotheses that in comparison to traditional approaches, computer-based educational games had stronger positive impacts on students' critical thinking skills and creativity.

Tucker and Abbasi (2015) collected data from almost 196 students at 4 Australian universities. Their findings posited that teamwork training that leads to the learning of team-working skills could improve the effectiveness of team performance. Focusing on design creativity, Casakin, (2007) assessed students' use of metaphor in design problem-solving. Results demonstrated that using metaphors contributes to design practice. Using metaphors can also help to develop expertise, stimulate creativity in design activities, and lead to stronger abilities in analysis, synthesis, and conceptual thinking.

Garaigordobil(2006) assessed the impact of a play program as an intervention on verbal and graphic–figural creativity in children aged 10 and 11 years. The results indicated that the intervention has a positive effect on stimulating creativity since the experimental participants significantly increased their verbal and graphic–figural creativity. Russ (2003) researched to examine if play can facilitate creative ability or not. It was found that play can facilitate creativity, insight, and divergent thinking ability.

Folkmann (2010) proposed a framework for describing and analyzing the workings of imagination in the creative design process. The design process can be regarded as a simulation process that can be improved by imagination.

Chang, Chien, Lin, Chen, and Hsieh (2016) scrutinized the auxiliary effects of three-dimensional computer-aided design (3D-CAD) on students' creative design. They collected data from 215 students studying in an anonymous senior high school in Taipei City, Taiwan. The findings of this present study demonstrated that 3D-CAD improved the students' creative performance, especially their expressiveness and functionality.

Ramaraj and Nagammal (2017) examined the feasibility of promoting thinking skills in architectural education through an open-ended task based on a dissection puzzle, 'TANGRAM'. They conducted their research in class as part of a 'theory of design' course, for the students in the fifth semester at the Department of Architecture, Sathyabama University, and Chennai. Findings suggested that puzzles are sources to frame various open-ended tasks to foster creativity and have the potentials to be introduced in the basic design studio, offered as a foundation course in architectural education across the nation.

Groenendijk, Janssen, Rijlaarsdam, and van den Bergh (2013) researched the role of observation in creativit.. 61 students (ninth grade) took part in an experiment with a pre-post-test control group design. They were randomly exposed to two conditions. Results suggested that observation had positive impacts on creativity in the design products compared to the direct strategy instruction for talented students, but not for low aptitude students. Participants in the observational learning condition showed more process learning experiences than the participants in the comparison condition, while participants in the comparison condition reported significantly more productive learning experiences.

Boden believed that the imposition of restrictions is a significant factor in stimulating creativity (as cited in Kowaltowski et al., 2009, p. 458). In the building design process, restrictions are present in terms of costs, site conditions, and so on. Restrictions are often regarded negatively as impositions, but they can be positive challenges for new ideas to flourish. Restrictions can act as stimuli in the design-studio to challenge students in surmounting imposed obstacles with creative and appropriate solutions. The strength of restrictions imposed on the design solution realm was tested by Kowaltowski et al. (2009). The results suggested that restrictions could enhance students' creativity, particularly by challenging students to break the imposed obstacles using adopting novel and original solutions. Additionally, with restrictions made clear, students got more confident in their design proposals and the design process as a whole. Turnbull et al. (2010) examined the advertising creative process used by agencies when developing new creative work. They argued that a curriculum that makes the students responsible for their learning process would encourage creativity.

In the presentation of design projects, Hargrove (2012) observed that students often have very accurate representations of the final product but lack the documentation to explain how they come up with a solution. In other words, documentation can help designers concentrate on their process, and recording this process increases their ability to build metacognitive knowledge. He claimed that:

> Writing and illustrating a personal log or project diary throughout a problem-solving experience or design project over some time causes students to synthesize thoughts and actions and translate them into symbolic form. This record also provides an opportunity to revisit initial perceptions, to compare the changes in those perceptions with additional experience, and to recall the successes and failures through experimentation with cognitive strategies. (p. 19)

Kowaltowski et al. (2009) probed the possible formal insertion of creativity enhancement tools. This study produced a list of some 250 methods, a large number of which was related to creativity in a wide range of areas: pedagogy, psychology, industrial design, business administration, marketing, fine arts, and architectural and engineering design.

Although creativity is highly desirable in the engineering design field, how to enhance creativity in design is still a question that many researchers attempt to answer. Yan et al. (2014) divided the creativity tools used in idea generation into two main categories: intuitive/unstructured tools and logical/structured tools. Intuitive tools include brainstorming, and logical and systematic tools involve TRIZ. Creativity tools fall into four categories: TRIZ, Synectics, Brainstorming, and Morphological analysis (p. 634).

Sielis et al. (2009) presented six creativity support tools: 1. mapping, 2. Mind Meister 3. Google Docs 4. Mind manager 5. Thinkature and 6. Triz. He argued that creativity support tools and techniques are powerful tools for the creative process and innovation. Liu, Yang, Yang, and Kao (2010) constructed a creative Universal Design approach that integrates both UD and TRIZ principles and the feasibility of this research results was manifested by a case study. It was found that the proposed approach incorporating TRIZ could reinforce the UD principles to come up with more concrete and creative solutions. This research also suggested that both UD and TRIZ principles could work together to provide more creative and inventive solutions that conform to UD requirements without the need to make trade-offs. This approach can be employed in product design and development with the systematic and creative problem-solving procedure.

DeHaan (2009) studied the role of instructional interventions in enhancing creativity. He argued that various creativity training programs involving brainstorming and creative problem-solving increase student scores on tests of creative-thinking abilities. Baillie (2006) examined the role of creative thinking techniques in enhancing students' creativity. She claimed that the contradiction matrix and 40 inventive principles of TRIZ provide the strongest solutions in the creative problem-solving process.

Birdi, Leach, and Magadley (2012) evaluated the impact of TRIZ creativity training in an organizational field. They reported that the engineers who participated in TRIZ training showed short-term improvements in both creative problem-solving skills and motivation to be innovative in there in the workplace. Thompson and Lordan (1999) cited an extensive international study conducted by Schlicksupp at the Battelle Institute. He classified

methods of creative ideas generation methods into six categories: "Brainstorming methods, brainwriting methods, methods of creative orientation, creative confrontation, systematic structuring, and systematic problem specification" (p. 23). They also proposed five main groups of creativity techniques that are of most relevance to engineers: brainstorming, synectics, morphological analysis, brainwriting, and check-lists.

Analyzing 9 of the collected researches related to our third research question: (What is the evidence for assessing creativity enhancement in architecture studios?) suggested that factors such as a person, product, and process and environment have a significant impact on the architecture studios. In their study, Aderonmu et al. (2019) stated that in assessing creativity, novelty is considered a key component criterion. Xiong et al. (2019) developed a qualitative-quantitative assessment model named GT-DANO-MV to systematically improve architecture students' creativity. This model allows experts to assess the effectiveness of assessment criteria aiming at evaluating the latent characteristics, novelty, and market value of design products.

Hargrove (2012) stated that design is considered the heart of the curriculum at virtually design schools. However, when designers and design educators use the term 'design' they focused more on the aesthetic and theoretical dimensions of design than on the cognitive nature of the process itself. The measure of learning equals the evaluation of the product of the design rather than the learning process or skill. Consequently, the cognitive skill sets of design are not sufficiently addressed, and important learning opportunities are marginalized (p. 8).

Creativity assessment in design conforms to "innovation in design". The evaluation of design creativity is one of the most important aspects of the educational curriculum in schools of design and architecture (Casakin & Kreitler, 2008). Design creativity assessment is a major issue in the educational curriculum in schools of architecture.

Hipple, (2003) introduced a very powerful tool named the Kirton KAI™ assessment tool that measures the problem-solving style of an individual. This tool assesses the individual's relationship to the problem-solving environment and the problem itself. The globally validated KAI™ includes 32 questions that can be answered in 15-20 minutes. Chulvi et al. (2012) designed an experimental study with 18 participants- including design, mechanical or industrial engineers- to compare the results achieved from using different design methods (brainstorming (BR), functional analysis(FA), and SCAMPER) in design processes. The results indicated that the amount of time spent on these three activities (problem identification, problem analysis, and problem choice) is much greater than when no method is applied. While there are still disagreements about how to measure design creativity, many creativity investigators agree that creativity is multidimensional. A creative product must be both novel and useful. A novel design is new, original, or surprising, and a useful design is functional, appropriate, correct, and valuable. Others contend that creative designs must also include properties such as detail and elegance. However, there is no agreement on these creativity criteria, and some regard novelty and usefulness as the only criteria for creativity (Chiu & Salustri, 2010, p. 2).

Ullman argued that creative ideas must be more than just good ideas; they must solve the problem. He added that creative ideas include a fundamental logic and value in addition to novelty. He emphasized concept generation techniques such as brainstorming, TRIZ, random stimuli, and biomimetic design. (cited in Chiu & Salustri, 2010).

Horn and Salvendy formed a conceptual product creativity assessment model within the context of the information processing model. They presented six product creativity factors; resolution, emotion, centrality, importance, desire, and novelty (cited in Demirkan & Afacan, 2012, p. 264).

Key concepts such as a person, environment, process, product, background knowledge, instructional interventions, creativity support tools, creativity-enhancing techniques, personal assessment, which have been addressed in many studies (see table 1), were found to be very helpful and effective in enhancing creativity in design studios. The frequency of creative elements in design studios is illustrated in Table 2.

Step Five: Analysis and Combination of Qualitative Data

At this step, the codes identified from the previous step are classified based on thematic similarities. In other words, similar codes or concepts fall into one category and create new concepts.

The content analysis method of 60 selected studies confirmed that the four factors of person, environment, product, and process are regarded by most researchers as important factors for creativity enhancement. (Thompson & Lordan, 1999; Casakin & Kreitler, 2006; Turnbull et al., 2010; Williams et al., 2011; Demirkan & Afacan, 2012)

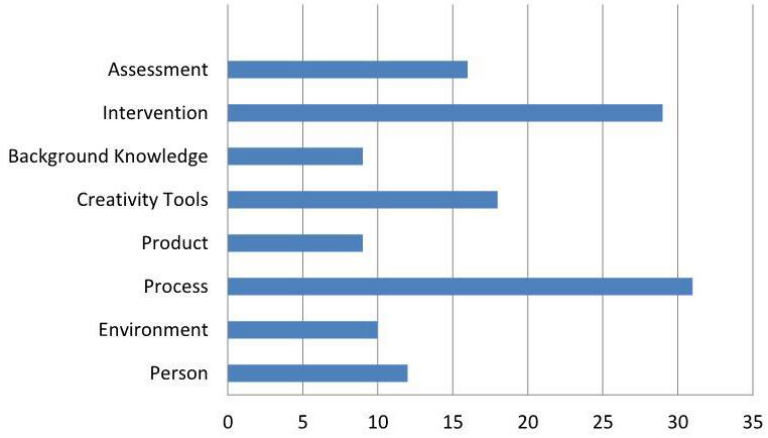
A large number of studies have confirmed that factors such as instructional interventions, creativity support tools, creativity techniques, and creativity assessment can enhance creativity in design studios. Therefore, we can divide these factors into three general categories according to the thematic similarities found in selected papers: 1- Conceptual elements of creativity (person, environment, product, and process); 2- Interventions (support tools, creativity techniques, background knowledge, instructional interventions). 3- Assessment.

In the next stage, the relationship between these three components was examined to figure out which of these creativity components are affected by educational interventions and creativity tools (Fig. 2). Furthermore, it was revealed that creativity assessment tools and evaluation factors are related to which of the creativity components. (Figure 3)

Table 1
Codes extracted from concept analysis of selected articles

	Authors	Person	Environment	Process	Product	Creativity tools	Background knowledge	Intervention	Assessment
1	Mahmoud et al (2020)	✓		✓					
2	Kremer (2019)	✓	✓	✓					
3	Aderonmu et al (2019)	✓						✓	✓
4	Casakin et al (2019)							✓	
5	Xiong et al (2019)								✓
6	Bereczki and Karpati (2018)	✓	✓					✓	✓
7	Ramaraj et al.(2017)					✓			
8	R. Keith Sawyer (2017)		✓						
9	Shan Chang et al (2016)					✓			
10	Tucker & Abbasi (2015)							✓	
11	Dan Davies et al (2014)			✓					
12	Y. Yan et al (2014)					✓		✓	
13	Dan Davies et al (2013)		✓				✓	✓	✓
14	P. Le Masson et al (2012)			✓			✓		
15	Casakin et al (2013)			✓				✓	✓
16	Talita Groenendijk et al (2013)							✓	
17	Chronopoulou & Riga (2012)							✓	
18	Kamal Birdi et al (2012)			✓		✓			✓
19	Kilicaslan & Efe Ziyrek (2012)	✓	✓	✓					
20	Demirkan & Afacan (2012)	✓		✓	✓				✓
21	Ryan Hargrove (2012)					✓	✓		✓
22	Clinton & Hokanson (2012)			✓					✓
23	Williams (2011)	✓	✓	✓					✓
24	Lee et al (2011)				✓		✓		✓
25	Casakin & Kreitler (2011)			✓			✓	✓	
26	Chulvi et all (2012)			✓	✓	✓		✓	✓
27	Hamalainen & Vahasantanen (2011)							✓	
28	Kowaltowski et al (2009)			✓		✓	✓	✓	
29	Folkmann, M. N (2010)							✓	
30	Chiu & Salustri (2010)					✓		✓	✓
31	Liu et al (2010)					✓			
32	Morag Turnbull et al (2010)	✓		✓		✓	✓	✓	
33	Rauth et all (2010)			✓		✓	✓		
34	Hasirci a & Demirkan (2010)	✓		✓	✓			✓	✓
35	Nilgün Kuloglu, Ali O. Asasoglu (2010)			✓				✓	
36	Casakin, Kreitler (2006)	✓	✓	✓					✓
37	Anthony Williams et al (2010)		✓	✓	✓				✓
38	George A. Sielis, Aimilia et all (2009)					✓	✓		
39	Pahl et al (2007)	✓	✓			✓			
40	DeHaan (2009)			✓		✓	✓	✓	
41	Lewis (2006)	✓		✓	✓		✓	✓	
42	Baillie (2006)			✓		✓			
43	Howard et al (2007)			✓		✓			
44	Casakin, Kreitler (2008)			✓				✓	✓
45	Tucker Richard & Reynolds Catherine (2006)			✓				✓	✓
46	Maite Garaigordobil (2006)							✓	
47	Hernan Pablo Casakin (2007)	✓		✓			✓	✓	
48	Kerrie and Sim (2009)							✓	
49	Sandra W. Russ (2003)							✓	
50	Caroline Sharp (2001)							✓	
51	Jack Hipple (2003)			✓	✓	✓			
52	Bill Nicholl (2004)	✓	✓	✓			✓		
53	Dorst, and Cross (2001)			✓					
54	Thompson and Lordan (1999)	✓	✓	✓	✓	✓			
55	Mahdavinejad (2005)			✓					
56	Hojjat (2004)			✓					
57	Sobhiyah, Bemanian, and Keshtiban (2008)			✓				✓	
58	Pir Khaefi, Borjali, Delavar and Eskandari (2009)							✓	
59	Boroon, Heidarie, Bakhtiar Poor and Boroon (2013)							✓	
60	Moradi and Norozi (2016)							✓	

Table 2
Frequency of creative elements in design studios based in selected articles



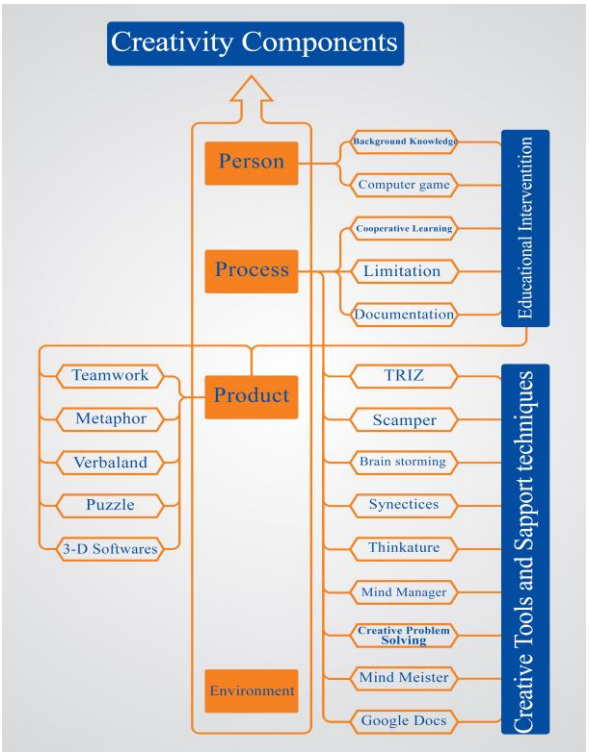


Fig. 2. The effect of educational interventions and creativity tools and support techniques on creativity components

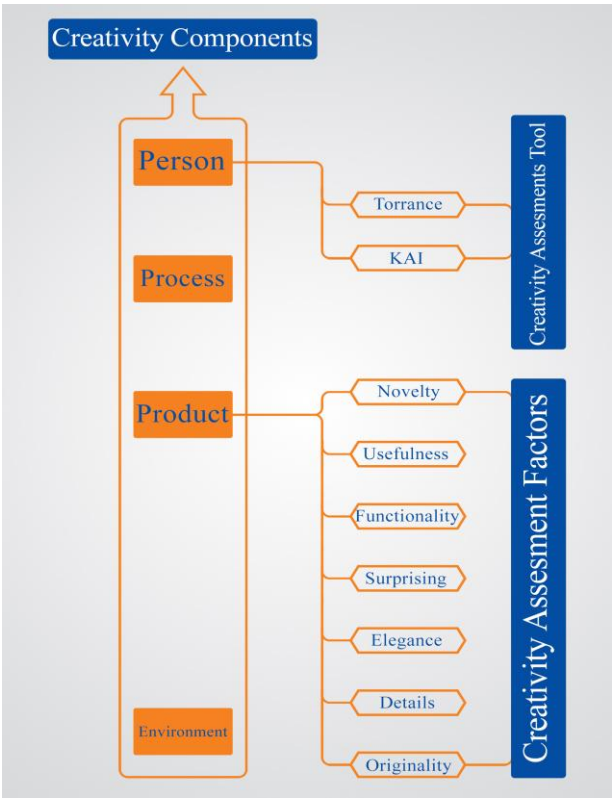


Fig. 3. The effect of creativity assessment tools and creativity assessment factors on creativity components

Step Six: Quality Control

During the meta-synthesis method, researchers select resources from reliable databases and did not study those resources without academic merits. In this way, the mentioned cases can guarantee the quality of findings of this research to an acceptable level:

1. Good quality literature searches and accurate reporting of these searches

2. Employing both electronic and manual searching methods
3. Applying the quality control methods used in authentic studies

Step Seven: Discussion and Conclusion

Over the past few decades, particular attention has been paid to creativity in universities and research. For example, there has been a great deal of research on the nature of creativity, creativity occurrence, and the factors affecting the creative process. Person, product, process, and environment are the four essential elements of creativity encouraging creativity. Creative people have several common characteristics: verbal validity, high intelligence, and motivation, flexibility, risk-taking, authenticity, tendency to identify problems, and confidence. They achieve a creative product in an appropriate place that is an important part of the creative process.

Also, it was found that creativity has many other facets and characteristics, such as instructional interventions and creativity enhancement techniques. Instructional interventions involve enhancing background knowledge, boosting imagination, observation, teamwork and cooperative learning, using homogeneous teams, art education, music, games, using puzzles and computer simulation, changing teaching methods and matching educational content with creative content, graphic presentation of ideas, critique and group discussions, introductory analysis, and the use of blogs.

There is a wide variety of tools and techniques for these interventions in a large variety of areas such as psychology, education, management, business, marketing, industrial design, and architectural and engineering design. Therefore, raising background knowledge and identifying appropriate tools and techniques act as interventions in the creative process. It should be noted that not all of these tools can be used in design studios. Brainstorming, SCAMPER, data analysis, biomimicry, Synectics, and Triz are the most effective tools to enhance creativity in the creative process.

Reviewing the extracted codes in creativity studies showed that creativity assessment is one of the key elements in creativity enhancement because assessing person, process, and the product is very significant in the process. Furthermore, continuous assessment throughout the process and selecting the appropriate intervention tools and techniques are also of great importance. Results suggested that creativity is a multi-faceted phenomenon, whose facets have been studied independently and abstractedly in the previous studies, while they should be viewed in an integrated and systematic manner. In other words, the integration of these factors helps creativity enhancement. For instance, factors such as a person, environment, product, and process are of great importance in encouraging creativity in design studios. Accordingly, the type of instructional interventions implemented in design studios needs to conform to the students' ability and aptitude. These interventions play a crucial role in enhancing creativity due to their significant impact on all the conceptual elements of creativity.

On the other hand, the role of assessment in design studios cannot be ignored since most of the problems in design studios are caused by this element. Therefore, it is vital to form an assessment system and mechanism to evaluate creativity during the creative process in studios that leads to creativity enhancement. Therefore, teachers need to be familiar with the conceptual framework of creativity to encourage it in students. By choosing appropriate intervention tools and assessment mechanism they can enhance creativity and evaluate interventions and identify the weaknesses of the creative process and interventions.

The educational model illustrated in Fig (4) can be utilized to enhance creativity in design studios. This model involves three main components of creativity (person, process, environment, and product), educational interventions along with support and assessment tools. These components are interrelated so that the initial assessment of creativity should be done in advance of the training to determine which of the creativity components need to be promoted and then to determine suitable tools and techniques. After the required intervention, secondary assessment is carried out to determine which of the creativity components are affected and predict the next interventions. This process is repeated until the final result is achieved.

In comparison to the prior research which generally divides the content of creativity into 4 components (person, environment, process, and product), this study has made use of the meta-synthesis method to deal with other factors such as interventions (including support tools and creativity techniques, educational interventions and background knowledge) as well as assessment (including individual, environmental, process and product assessment). It is concluded that by applying all these three categories in an integrated way, the desired result, which is creativity enhancement, can be achieved. Therefore, considering the crucial role of creativity in design studios, the current study acts as pioneering research and its results have many applications in design studios. Therefore, there is a need for experimental research to analyze more resources on architectural and design studios to elicit their implicit aspects to determine the appropriate assessment and intervention mechanisms in design studios. Additionally, because there has been no reliable research on environmental assessment, future investigations are required to focus on this factor.

Fig. 4. Educational Model of Enhancing Creativity in Design Studios

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