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Original Research Article

Empowering Creative Architectural Design Education Utilizing C-K Theory and Countering the Fixation Effect

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Abstract

Problem statement: Creativity and innovation are essential components in architectural design education and play a decisive role in generating new ideas and solving complex spatial problems. However, traditional approaches to architectural education often lead to a decline in creativity and the emergence of the "fixation effect," which is a serious barrier to divergent thinking. The current study is based on the premise that the application of Concept-Knowledge (C-K) theory and metaphor-based techniques can lead to a reduction in the cognitive fixation effect and the enhancement of creativity in architectural design education.

Research objective: This study was conducted with the aim of presenting a hybrid framework to enhance creative architectural design education, based on Concept-Knowledge (C-K) theory and the Zaltman Metaphor Elicitation Technique (ZMET).

Research method: The present study was conducted using a qualitative approach, utilizing the Zaltman Metaphor Elicitation Technique in connection with C-K theory. In this process, 10 architecture students used images to represent their mental concepts and unconscious experiences regarding creativity and design limitations. Subsequently, the data were analyzed, and a consensus mental map was extracted to identify the key components of creativity and strategies to counter the fixation effect.

Conclusion: The results indicate that the simultaneous use of the C-K framework and metaphorical activities increases students' intellectual freedom, creative energy, divergent thinking, and ability to overcome mental limitations. Furthermore, the intensity of the fixation effect decreased in some participants, paving the way for the formation of more innovative design pathways. Additionally, integrating C-K theory with metaphorical techniques can provide a practical and effective framework for creative architectural design education, playing an effective role in fostering creative thinking and reducing cognitive fixation.

Keywords: *Creative education, innovative skills, Concept-Knowledge (C-K) theory, divergent thinking, cognitive fixation.*

Introduction

In today's world, architectural design education faces complex and diverse needs, where creativity and innovation have become increasingly important as key skills. However, research shows that traditional approaches to architectural education (transmission-based and pattern-based approaches) typically reduce students' levels of creativity and critical thinking; such that, over time, students experience cognitive fixation, and their ability to present innovative solutions in the design process diminishes (Mohammadi et al., 2016). In

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architectural education, this situation is observed through several common educational patterns, including an overemphasis on reproducing known forms, a heavy reliance on teacher-centered design paradigms, and a focus on evaluating the final result rather than the ideation process. In many design studios, the educational process is sometimes limited to following previous examples or established patterns; an issue that can reduce the scope of students' conceptual exploration and lead to design fixation (Jansson & Smith, 1991; Cross, 2001). This "fixation effect", as one of the main barriers to creativity, stems from habituating to previous solutions and thought patterns, which ultimately restricts innovation and the emergence of new ideas.

On the other hand, Concept-Knowledge (C-K) theory, as a scientific and systematic framework, enables the modeling of creative thinking and the design process. It has been shown that by separating the concept space and the knowledge space, ideation and innovation processes can be improved (Nabi-Pour Afrouzi & Darvish-Motevali,, 2013; Hatchuel et al., 2017). This theory not only helps in better understanding the interaction between knowledge and concepts but also, by structuring design reasoning, increases the ability to counter cognitive limitations such as the fixation effect (Agogué & Poirel, 2019).

Despite the importance of C-K theory and its impact on enhancing creativity and innovation, its effective and practical application in architectural design education has not yet been adequately developed. Furthermore, creative training is usually provided sporadically and without a precise theoretical framework, making it less effective in strengthening creative design skills (Hosseini et al., 2019).

Despite the growing body of studies on creativity in architectural education, a significant portion of research has focused on introducing creativity techniques like brainstorming, SCAMPER, or ideation methods, paying less attention to systematic theoretical frameworks for guiding the design process. While utilizing these techniques has been effective, without a strong theoretical foundation, they cannot comprehensively transform educational processes.

In recent years, Concept-Knowledge (C-K) theory has been proposed as one of the important analytical models for explaining the logic of creative design; however, its practical application in architectural educational environments, especially for novice students, has not yet been widely investigated. In addition, current research has paid less attention to the role of unconscious mental processes and cognitive metaphors in activating the conceptual space. Therefore, the main research gap in the existing literature is the lack of an integrated approach that simultaneously utilizes the C-K theoretical framework and tools for extracting unconscious concepts to reduce the cognitive fixation effect in architectural design education.

Thus, conducting such research seems necessary to not only investigate and utilize C-K theory but also to present strategies for empowering creative architectural design education within a structured framework. By purposefully countering the fixation effect, it can pave the way for the growth of creative thinking and innovation in architecture students. Therefore, the current study was developed with the aim of filling this gap and providing novel educational strategies based on C-K theory and countering cognitive fixation.

Literature review

Sola et al. (2017), in a study titled "An Investigation of the State of Creativity and Critical Thinking in Engineering Undergraduates," evaluated changes in these two key skills throughout the academic program. Referring to Torrance's (1988) perspectives on the nature of creativity, they used the Torrance Tests of Creative Thinking (figural) and the Watson-Glaser Critical Thinking Appraisal to measure student performance. The findings indicated that first-year engineering students were significantly more creative than final-year students, whereas no significant difference was observed in critical thinking between

the two groups. Even compared to normative data, final-year students performed worse in critical thinking than their peers in other disciplines. These results, considering the study's limitations, suggest that the engineering education system not only reduces creativity but also weakens critical thinking capacities over time. Hence, the authors emphasize the need to revise educational methods to strengthen and preserve these vital skills.

Sheykh and Younesian (2015), in a study titled "Design Based on Concept-Knowledge Theory: Graph-Based Modeling in Concept and Knowledge Space," investigated a novel approach in the design process based on C-K theory. Emphasizing the importance of conceptual and knowledge modeling, they attempted to analyze the design process within a graph-based system. In this research, simulation tools were used as a valid scientific method to represent and examine design structures. According to the authors, C-K graph modeling can lead to a better understanding of the interactions between the knowledge space and the concept space. Utilizing JUNG software and network analysis, they demonstrated that this approach is capable of activating design reasoning and providing a context for creating innovative ideas.

Armand Hatchuel et al. (2017) also examined the C-K theory framework, which formally and scientifically models creative thinking, in a study titled "C-K Theory: Modeling Creative Thinking and Its Impact on Research." By emphasizing concepts such as "concept undecidability," "knowledge independence," "expansive partitions," and "knowledge reordering," they explained the key mechanisms of the creative process. They showed that C-K theory can reveal important aspects of creative thinking that have been overlooked in classical interpretations. This theory covers creative ideation, learning, invention, discovery, and knowledge expansion within a single model and, with its explanatory and predictive power, establishes a novel relationship between theory and observation in the field of creativity. Their research also contributes to the development of a rigorous science of design and stimulates interdisciplinary research in the field of creativity.

Agogué and Kazakçi (2014), in a study titled "[10] Years of C-K Theory: A Survey on the Academic and Industrial Impacts of a Design Theory," comprehensively reviewed the impacts of C-K theory in academic and industrial domains over a decade. Taking a foundational approach, they studied C-K theory as a scientific phenomenon to discover what is expected from a design theory and to what extent such a theory can be influential in different environments. In this study, in addition to analyzing sources published in English and French, they also utilized interviews and feedback from students and industrial partners who had used C-K theory-based tools and methods. The findings showed that C-K theory has expanded rapidly over the past decade and has left numerous impacts. The authors, emphasizing features such as generality, generativity, and connectivity with contemporary sciences, believe that C-K theory can act as a reference framework in explaining the creative logic of design. Furthermore, through analyzing theoretical and practical contexts, they emphasized that this theory, besides design engineering, has also found applications in fields such as management, psychology, philosophy, and even ecology. This research was financially supported by the French government and industrial institutions like Dassault, RATP, and Thalès, and according to the authors, it demonstrates the high capacity of C-K theory in producing innovative knowledge and enhancing design capabilities at various levels.

Kazakçi et al. (2014), in a study titled "Brainstorming vs. Creative Design Reasoning: A Theory-Driven Experimental Investigation of Novelty, Feasibility, and Value of Ideas," compared two common approaches to idea generation: traditional brainstorming and the theory-driven creative design approach. By designing an experimental setup, they evaluated the performance of these two methods in producing ideas characterized by novelty, feasibility, and economic value. Their research was structured around the Concept-Knowledge (C-K)

theory and sought to demonstrate how design reasoning based on this theory can yield different outcomes compared to brainstorming. In this study, groups of participants performed specific design tasks using one of the two mentioned methods. The analysis of the results showed that the C-K reasoning-based design approach had a higher ability to produce innovative, valuable, and feasible ideas compared to traditional brainstorming. The researchers argued that the structured and directional nature of C-K theory helps activate creative logic and can reduce the cognitive limitations commonly found in the idea generation process. This research, highlighting the importance of theoretical frameworks in the design process, offers a fresh perspective on the effectiveness of creativity tools.

Smith and Finke (1999), in the "Creative Thinking" chapter of the Handbook of Creativity, examined the cognitive processes involved in generating creativity. Emphasizing the innate capability of human cognition in producing new ideas, they introduced the heuristic model of creativity, which includes cognitive processes, structures, and limitations. They also discussed the concept of "family resemblance" in creative thinking, the role of insight, conceptual expansion, conceptual combination, and creative imagery. Findings from the reviewed studies indicate that creativity is not only a goal-oriented ability but an exploratory and expansive process encompassing both domain-specific and general cognitive skills. This chapter contributes to resolving long-standing disputes about the nature of creativity by analyzing these perspectives and emphasizes the importance of structured cognition in creative processes.

Marine Agogué et al. (2019), in the book Design Theory and the Fixation of Creative Skills explored the effects of age and education on the creative process. This book looks at creativity through an educational lens, presenting it as a fundamental and vital issue in modern education. Using C-K theory, the authors provide a theoretical framework for modeling the fixation phenomenon, defining the fixation effect as a set of restrictive heuristic problem-solving methods based on past experiences that are activated during the creative reasoning process. Agogué and Poirel delve into concepts such as the impact of age on design fixation, the role of education in reducing or exacerbating this effect, and modeling the distribution of creative solutions. They demonstrate how the fixation effect, as a cognitive barrier to innovation, is influenced by individual and environmental factors, and how structured education can serve as an effective agent in developing creative skills. This book, by presenting empirical evidence and theoretical analyses, frames creativity not just as a skill, but as a complex, multidimensional process in which education and age play decisive roles. It also helps clear up ambiguities and disagreements in the field of creativity education and stresses the importance of targeted instruction for nurturing creativity.

Mahdavi-Nejad (2005), in an article titled "Creativity and the Creative Education Process in Architectural Design," examined the role of creativity in architectural design education. Emphasizing the necessity of understanding the concepts of intelligence, imagination, and creativity as the core pillars of the creative process, he sought to explain the factors that foster a creative mind during architectural design. The study identifies targeted education, self-confidence, practical experience, and the creation of an appropriate intellectual and environmental context as key components in enhancing architecture students' capabilities. The author believes that revising educational methods and employing logical and deductive reasoning can lead to the growth of students' spatial and intellectual creativity. This article provides strategies for guiding the design process, laying the groundwork for improving the quality of architectural education, and emphasizing the importance of structured, targeted educational planning.

Tayyah and Mehdizadeh Saradj (2025), in an article titled "Effective Components in Assessing the Creativity of Novice Architecture Students,"

investigated the factors influencing creativity in the design process and final products of beginner architecture students. Emphasizing the non-linear stages and flexibility of design, including environmental awareness and comprehension, imagination and the unconscious, abstract thinking and metaphor, and rationality, they sought to identify key components for enhancing design creativity. Criteria such as attention to initial data, the use of unique ideas, aligning the design with future goals, and the physical, conceptual, and spatial aspects of the final product were introduced as effective factors in developing students' creative abilities. The authors believe that purposeful attention to these components at various design stages can significantly elevate novice students' creativity, providing a foundation for creative and innovative architectural education.

Nejati et al. (2022), in an article titled "Critique and Review of Critique-Based Education in Architectural Design," explored the role of critical thinking and critique in architectural education. Stressing the importance of analytical skills, reasoning, and the evaluation of design works, they aimed to clarify the place of critique-based education and scientific review in fostering the cognitive skills of architecture students. Providing continuous feedback, enabling two-way dialogue between professors and students, and creating a supportive, flexible environment for critiquing and analyzing designs were presented as key elements in boosting student capabilities. The authors argue that applying critique-based educational methods and focusing on the development of critical thinking can dramatically increase students' analytical skills, spatial creativity, and independent decision-making abilities. This study, by offering strategies for implementing scientific critique in architectural studios, paves the way for improving the quality of design education and highlights the need for targeted, structured educational planning. Mozaffar et al. (2007), in an article titled "The Role of Neighborhood Open Spaces in the Growth and Creativity of Children," examined how these spaces contribute to children's physical and social development and foster their creativity. Emphasizing the importance of open spaces in children's daily lives, the authors sought to identify the criteria affecting the quality of these areas. Factors such as proper accessibility, age-appropriate scale, attractiveness, safety, comfort, and participation were introduced as key indicators for strengthening social interaction, a sense of belonging, and the blossoming of children's creative talents. They believe that the active participation of children in designing playgrounds and local parks can lay the groundwork for their creative growth and increase their presence in urban environments. Talebi et al. (2021), in a study titled "An Analysis of the Effectiveness of Creativity Training Techniques on Architectural Design with an Emphasis on the Ideation Process," investigated the impact of creativity training on the mental and design capabilities of architecture students. This experimental research utilized a pre-test/post-test design with control and experimental groups. The participants consisted of undergraduate architecture students who were randomly assigned to two groups of 20. The study aimed to assess the effectiveness of techniques like brainstorming, SCAMPER, and problem-solving thinking on ideation processes and creative problem-solving in design.

Recent studies have also emphasized the importance of theoretical approaches in creative design education. For instance, recent research shows that using conceptual design models can structure students' ideation processes and help reduce cognitive limitations during design (Hatchuel et al., 2009; Dorst, 2017).

The results of the statistical analysis (using independent t-tests and SPSS software) showed that training in these techniques had a significant effect on improving the creativity and quality of the students' design processes compared to the control group. This study emphasizes that utilizing structured creativity training methods can play an effective role in improving the ideation process in architectural design education.

• **Literature summary**

Sola et al. (2017) reported a decline in creativity and critical thinking among engineering students over their course of study and emphasized the need for educational revision. Sheikh and Younesian (2015) and Armand Hatchuel et al. (2017), using Concept-Knowledge (C-K) theory, provided a scientific framework for modeling creative thinking and innovative design, facilitating the empowerment of the design process. Agogué and Kazakçi (2014) showed that this theory produces more innovative and practical ideas compared to traditional brainstorming methods. Furthermore, Marine Agogué et al. (2019) identified cognitive fixation as a barrier to innovation, proposing targeted education as a solution. In architectural education, Mahdavi-Nejad (2005) highlighted the role of creativity and practical experience in nurturing a creative mind, and Talebi et al. (2021) confirmed the effectiveness of creativity training techniques like brainstorming and SCAMPER in improving architecture students' ideation processes. All these studies underscore the importance of utilizing C-K theory and countering the fixation effect in creative architectural design education.

Despite the value of previous studies, a critical review shows that a significant portion of the research has either focused on assessing students' creativity levels or introduced ideation techniques, while less attention has been paid to designing a cohesive theoretical framework to guide the creative process in architectural education. Furthermore, many of these studies have examined creativity as an individual trait and paid less attention to the cognitive mechanisms of idea formation through the interaction between knowledge and concept. In this context, C-K theory can provide a theoretical foundation for analyzing this process, but its application in architectural educational environments remains neglected.

• **Research gap, questions, and hypotheses**

Based on the reviewed literature, several research gaps were identified:

-A lack of studies practically applying C-K theory in architectural design education.

-The absence of research examining the integration of the Zaltman metaphor technique and C-K theory to reduce the fixation effect.

-A scarcity of studies related to extracting the unconscious concepts of architecture students during the design process.

Therefore, this research was conducted to fill these gaps. Its main question is: What role does the application of Concept-Knowledge theory in architectural design education play in reducing cognitive fixation and increasing students' creativity? Based on the hypothesis of this research, it seems that utilizing the Concept-Knowledge (C-K) theory in architectural design education improves students' creativity and reduces their cognitive fixation in the design process. Expanding the conceptual space and redefining the relationship between knowledge and ideas, it enables the formation of innovative solutions.

• **Zaltman metaphor elicitation technique and its background**

The Zaltman technique, or ZMET for short, was first introduced by Gerald Zaltman in 1994 and has since been used as an advanced tool for the qualitative analysis of individuals' mental experiences. This image-based technique was designed to extract individuals' mental patterns (Tayyah, 2020) and is founded on the core assumption that over 95% of thought processes occur in the human unconscious mind, and traditional questionnaire methods or explicit interviews lack the ability to access these deep layers (Zaltman, 2003). In an effort to understand the audience's mind and hidden cognitive structures, Zaltman invented an image-based method for extracting metaphors and mental maps, which was widely embraced in various fields of the humanities and design. Zaltman relies on the use of visual images and metaphors to identify the mental, emotional, and cognitive concepts hidden in individuals' unconscious layers. By relying on respondents' active participation in collecting and interpreting images meaningful to them, this method

allows for the extraction of mental structures, attitudes, and internal perceptions. The high validity of the results obtained from this technique in discovering deep mental data distinguishes it from many traditional qualitative methods, such as open interviews and focus groups (Tayyah et al., 2020). In the Zaltman execution process, after participants gather images, semi-structured, metaphor-based interviews are conducted, and a mental map is then drawn for each individual. In the final step, analysts combine the individual maps to reach a consensus map that reflects the target group's collective mental model (Coulter et al., 2001). The visual nature of this method has made it an effective tool for understanding spatiality, visual perception, and spatial communication. For this reason, in recent years, this technique has found a special place in architectural and design studies, particularly in the context of education and experiencing space (Luoma, 2003). For example, Lincourt used the Zaltman technique to study architecture students' perceptions of gardens and landscapes. He selected 9 architecture students and asked them to collect images related to their personal interpretations of ideal landscapes. The analysis of the resulting metaphors demonstrated how users' hidden knowledge could be leveraged for more meaningful architectural designs. The findings of this study showed that the ZMET technique is effective in enhancing architects' understanding of user preferences and translating visual concepts into environmental design. Additionally, the Astorino Architectural firm, in projects such as the Children's Hospital of Pittsburgh and an apartment complex, utilized Zaltman to gain a deep understanding of the feelings of patients, families, and staff. In these projects, participants selected images that symbolized care, safety, healing, and peace for them. Analyzing these images led to the discovery of key metaphors that played a significant role in designing the new healthcare spaces (Conley, 2005).

In another study, Chiu and colleagues investigated children's understanding of biodiversity through the Zaltman technique. Using images and clips containing various crab species, they analyzed children's perceptual structures regarding animal classification, sense of difference, and biological attractiveness. This study showed that even in younger age groups, this technique is capable of extracting complex cognitive concepts that are inaccessible through traditional methods (Tayyah et al., 2020).

Research results show that utilizing Concept-Knowledge (C-K) theory in architectural design education increases students' creative capabilities and establishes a strong, stable connection between the design process and natural inspiration. This approach has led designers to believe that integrating innovative ideas with natural patterns facilitates and strengthens the development of design concepts. This method consists of three main stages: pre-interview, interview, and post-interview, each of which is detailed operationally below (Fig. 2). Applying this method within the C-K theory framework can break restrictive thought patterns when countering the cognitive fixation effect, thereby increasing creativity in architectural design education.

Theoretical Framework

• Creativity in architectural design education

- The importance of creativity in architectural design

The architectural design process encompasses various decisions and their evolutionary stages (Tayyah et al., 2020). It is a process in which the designer must provide innovative solutions for spatial and functional problems by utilizing imagination, intuition, technical knowledge, and contextual understanding. In architectural education, the cultivation of this skill is achieved through purposeful educational processes, design exercises, critical feedback, and the development of problem-solving abilities (Shafiipour Yurdshahi et al., 2016). Creativity is recognized as the essence of the architectural design process; understanding creativity can lead to a proper comprehension of its impact on the architectural design process (Tayyah et al., 2021).

- Existing challenges in creative architectural education

Traditional educational systems[1] typically emphasize the repetition of patterns, the transfer of prior knowledge, and the production of predictable results. This trend leads to a reduction in innovation capacity and the emergence of a phenomenon known as cognitive fixation among students (Shirvani Shiri et al., 2023). In this state, students become dependent on familiar solutions and fail to discover and expand upon new concepts.

• Concept-knowledge (C-K) theory

- Introduction to C-K theory

C-K theory, founded by Armand Hatchuel, Pascal Le Masson, and Benoît Weil, is a framework for modeling creative processes in design. By mentally separating two spaces, the Knowledge Space and the Concept Space, this theory enables the structured analysis and guidance of ideation processes (Prabaharan et al., 2019).

• Components of C-K Theory

-Knowledge (K-Space): Includes verified and valid information, scientific principles, existing technologies, and prior experiences.

-Concepts (C-Space): Includes ideas and propositions whose truth or falsehood has not yet been proven, and where innovation takes shape.

-Development Process: According to C-K theory, innovation occurs through continuous and systematic movement between these two spaces; concepts are enriched by the development of knowledge, and knowledge is reconstructed by the stimulation of concepts (Sheikh & Younesian, 2015).

- Advantages of C-K theory in architectural design

-Ability to model the design process in the form of a conceptual graph (Sheikh & Younesian, 2015).

-Structuring design reasoning and reducing the fixation effect (Bannon & Kuutti, 1996).

-Creating opportunities to develop innovative pathways by distancing from established knowledge (Babaee Farsani & Rahimpour, 2019).

• Cognitive fixation

- Definition and origin of the fixation effect

Cognitive fixation, or the "fixation effect," refers to a state in which a designer or idea creator loses the ability to discover new and innovative solutions or pathways due to a deep dependence on prior knowledge, past experiences, or conventional and common patterns. This effect causes the individual to remain trapped within limited intellectual frameworks, preventing them from seeing more creative options (Azar et al., 2020). In other words, fixation restricts thinking to known pathways and reduces innovation and creativity (Tayyah et al., 2020).

The fixation effect is common in design education environments where there is a strong emphasis on accepted solutions, standard techniques, and fixed frameworks. These environments may subconsciously cause individuals to explore novel and unknown pathways less frequently, thereby limiting critical and creative thinking (Mozafar et al., 2009).

Studies indicate that the fixation effect stems from two main factors: first, previous learning and experience that create stable mental patterns resistant to change; second, environmental or educational pressures that emphasize the acceptance of existing and known solutions while paying less attention to innovation (Khorshidi & Hosseinpour, 2015). Together, these two factors cause individuals to fall into the trap of fixation, making it difficult for them to easily move beyond previous intellectual frameworks.

- The impact of fixation on architectural education

The fixation effect in the architectural education process significantly impacts the quality and course of students' learning. This phenomenon causes students to resort to repeating conventional and previous patterns and solutions instead of creating new and original ideas. Under such conditions, designs usually gravitate toward clichés and predictable forms (Nadimi, 1999), which can seriously limit creativity and innovation in architectural projects. One of the major consequences of the fixation effect is a reduction in the diversity of ideas, as students remain within repetitive and limited intellectual frameworks and fail to search for fresh and different options. This situation also leads to a decline in the ability for divergent thinking[2], which is one of the key skills in architectural design and involves generating

multiple solutions or ideas for a specific problem (Lawson, 2005).

Furthermore, cognitive fixation can lead to a decrease in students' motivation to explore and experience unusual and risk-taking solutions, as they are mostly looking for solutions that have proven successful in the past or are recognized as the "correct solution" by professors and educational resources. Ultimately, this causes the architectural education process to not go beyond teaching rote memorization and imitation, thereby restricting the development of creative and innovative skills (Mahmoodi & Bastani, 2018).

- The role of education in reducing fixation

As one of the major barriers to the process of creativity and innovation, the fixation effect can significantly limit individuals' ability to discover new ideas and novel solutions. However, various studies have shown that designing and implementing targeted and structured educational programs can help break these fixed mental patterns and guide individuals toward more creative thinking (Manavi-Pour, 2010). One of the successful approaches in this area is education based on C-K theory, which emphasizes developing new concepts by combining existing knowledge with new ideas. Educational programs designed based on this theory provide clear, step-by-step frameworks that help students break free from the limitations of prior knowledge and open up new pathways for ideation (Coateana et al., 2010).

• Interaction of C-K theory and the fixation effect

- C-K Theory as a tool to counter fixation

C-K theory helps open the designer's mental space by continuously redefining concepts and separating them from established knowledge. In this process, the designer crosses the boundaries of the known and enters unknown and experimental territories, leading to the emergence of new and original ideas (ibid., 2010).

- C-K-Based design in educational environments

In the architectural design educational environment, teaching C-K-oriented techniques (such as developing conceptual graphs, separating knowledge and concept, and reverse design) can guide students toward creative ideation and away from mental clichés. Creating a design studio environment centered around exploration and the redefinition of concepts provides a suitable platform for the growth of creativity (ibid., 2010).

• Complementary theoretical approaches

- Heuristic model of creativity

The model proposed by Smith and Finke is one of the prominent theoretical frameworks in the field of creativity, which describes the process of creating new ideas in several key stages. This model includes four main stages: exploration, combination, insight, and creative imagery. The exploration stage deals with collecting and identifying knowledge and information related to the topic; the combination stage involves integrating various elements and concepts innovatively and unexpectedly; the insight stage occurs when an individual suddenly reaches a new understanding or solution; and finally, the creative imagery stage involves visualizing and representing fresh ideas. This framework aligns with the structure of C-K theory, as both emphasize the role of activating existing knowledge, expanding the scope of concepts, and the unexpected and creative combination of elements (Hatchuel et al., 2004). In other words, Smith and Finke's model not only explains the cognitive processes behind creativity but also demonstrates how an individual's prior knowledge and experiences can be combined to lead to the creation of novel ideas.

- Constructivist learning theory

Constructivist learning is one of the fundamental theories in the field of education, emphasizing the principle that learning is only meaningful and effective when the learner actively participates in the process of creating meaning and understanding new concepts. This theory is built on the foundation of experience, continuous reflection, hypothesis testing, and the redefinition of knowledge. In this approach, rather than passively receiving mere information, the learner constructs and develops concepts and knowledge through an active interaction process with the environment (Hatchuel et al., 2004). This perspective perfectly aligns with the principles of the C-K model

in the creative design process, because in the C-space, individuals engage in creating and developing new concepts, which requires active involvement with knowledge and experience (Dabiri, 2021). Thus, constructivist learning not only explains the cognitive process of learning but also highlights the important role of experience and experimentation in developing creativity and innovation. Although the heuristic model and constructivist theory were not used directly in the methodology, these two frameworks served a supportive role in analyzing and interpreting metaphors; meaning that the process of creative imagery and the gradual construction of new concepts could be explained in light of these two approaches. Fig. 1 shows the conceptual framework of the research, which is built upon three main theoretical axes.

1.The principles of C-K theory in developing the concept space.

2.The role of cognitive fixation in limiting the design process.

3.The extraction of unconscious metaphors as triggers for activating the C-space.

In this framework, Zaltman's metaphorical activities act as cognitive input, stimulating the concept space and bypassing fixed knowledge, thereby leading to the formation of new design pathways. This model is not merely a workflow process; rather, it is designed based on the theoretical relationships among the components of creativity, cognitive fixation, and concept development in C-K theory.

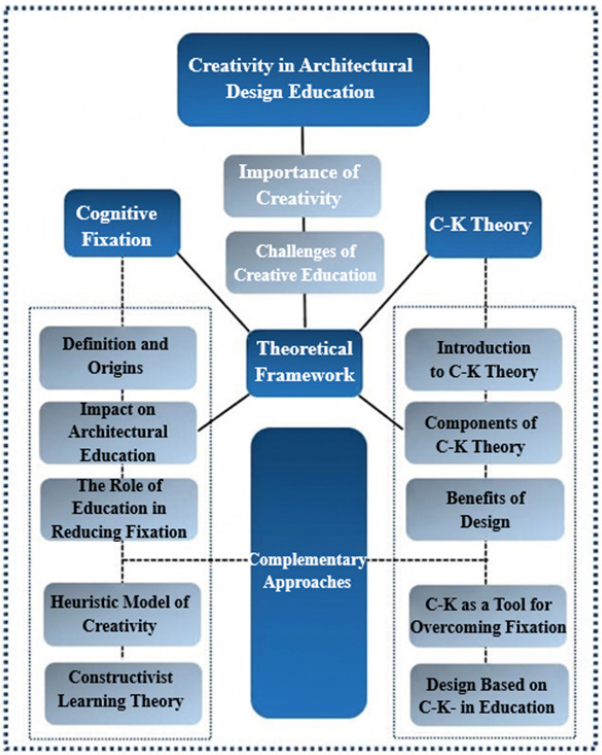


Fig. 1. Conceptual framework of the study. Source: Authors.

Research Methodology

In this research, purposive sampling was conducted among novice architecture students. The basis for this selection was the group's relevance to the research problem and objective. Since the current study, utilizing the Zaltman Metaphor Elicitation Technique, sought to deeply explore the mental experiences and semi-unconscious layers of students confronting creativity and mental fixation in the architectural design process, focusing on novice students, as a group, in the initial stages of forming design thinking patterns, was deemed appropriate. Additionally, according to findings from studies related to cognitive fixation, this phenomenon is more pronounced at the preliminary levels of design education; therefore, examining novice students allows for a more precise identification of cognitive mechanisms that limit creativity. Given the qualitative nature of the research, determining the sample size was based not on the logic of statistical generalization but on the adequacy of information and achieving theoretical saturation. Accordingly, 10 architecture students participated in the research process. After conducting in-depth interviews and analyzing the data, the repetition of conceptual patterns and extracted themes indicated that the data had reached an appropriate level of theoretical saturation. Therefore, this sample size was evaluated as sufficient to achieve a deep understanding of the participants' mental structures and analyze the patterns related to creativity and mental fixation.

In this research, the Zaltman Metaphor Elicitation Technique was utilized for an in-depth analysis of the unconscious experiences of architecture students when facing creativity and mental fixation. The selection of novice students was based on the theoretical logic of the research; the basis for this choice was the group's

alignment with the research problem and objective. Because the current study, using the Zaltman metaphor technique, aimed to deeply investigate the mental experiences and unconscious layers of students confronting creativity and the mental fixation effect in the architectural design process, focusing on novice students, as a group at the beginning stages of forming design thinking patterns, was considered suitable. Furthermore, considering findings from studies related to cognitive fixation, this phenomenon manifests more strongly at early levels of design education; hence, studying novice students provides the opportunity to more accurately identify cognitive mechanisms that restrict creativity.

- **Data analysis method**

Data were analyzed using Thematic Analysis based on the steps proposed by Braun and Clarke (2006). The steps included familiarization with the data, generating initial codes, searching for themes, reviewing, final defining, and reporting. To increase the accuracy of the analysis, coding was performed by two researchers, and disagreements were resolved through final consensus.

To enhance the validity and reliability of the results, several qualitative strategies were employed. First, data coding was conducted independently by two researchers, and differences of opinion were resolved through discussion and final agreement. Second, member checking (participant review) was used to confirm the interpretation of the metaphors. Additionally, efforts were made to increase the transparency of the analytical process by providing quotes and conceptual evidence from the data.

- **Executive stages of the research**

In this research, the Zaltman technique was used to identify unconscious concepts related to design creativity and the mental fixation effect. To this end, novices selected symbolic images from various sources (architectural magazines, websites, personal photos, natural environments, and the researcher's archive). The selection of images was conducted in a semi-guided manner, meaning that the general framework (creativity in design and mental limitations) was specified by the researcher, but the choice of theme and visual content was left completely free to reduce bias, representing their understanding of the design process, creativity, or mental limitations. These images were analyzed within the format of semi-structured interviews and, utilizing C-K theory, helped in mapping the students' mental structures and identifying the barriers to creativity in architectural education. Fig. 2 illustrates the research implementation process in detail.

Table 1 displays a sample of the selected metaphorical images and their conceptual interpretation, indicating that students are often influenced by past experiences and mental frameworks and need guidance toward the concept space (C) to enhance their creativity. Images such as the "suspension bridge" and "flowing water in rock" express the ability to overcome mental constraints[3] and activate creative thinking, while the "withered flower" and "bird in a cage" represent the fixation effect and the limitations of traditional approaches to architectural education. This analysis shows that utilizing C-K theory and metaphorical activities can guide students toward novel ideas.

- **Demographic characteristics of the statistical sample**

The results of the descriptive statistics for demographic characteristics are as follows.

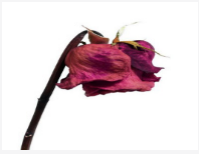
As seen in Table 2, the majority of respondents were in the 31 to 40 age group and held a Master's degree, indicating their specialized understanding of the research topic.

- **Categorization of extracted concepts**

After extracting the metaphors, the data were categorized based on key components of creativity and design capability. Table 3 shows the dominant mental patterns of the students and their focus on various aspects of creativity. This table helps to identify the students' mental strengths and weaknesses in the design process and to establish appropriate educational pathways to counter the fixation effect.

In this categorization, it became clear that students paid the most attention to intellectual freedom[4] and creative energy[5]. This indicates that students need more opportunities to break out of educational limitations.

Table 1. Metaphorical images selected by novice architecture students and the analysis of mental concepts related to creativity. Source: Authors.

Novice Code	Title	Image	Reasons for Selection – Related to Creativity and C-K Theory
1P	Suspension bridge in the forest		It symbolizes crossing from the fixed knowledge space to the unknown and creative conceptual space.
2P	Flowing water in rock		It indicates fluid creativity within a hard knowledge context, expressing the ability of design to bypass limitations.
3P	Withered flower		It reflects the fixation effect; endless repetition of similar ideas destroys creativity.
4P	Eye of a wild animal		It serves as a metaphor for a divergent look, showing the power of observing outside default frameworks.
5P	Bird in a cage		It represents a feeling of being restricted by traditional educational structures, emphasizing the need for intellectual freedom.
6P	Spiral path		The creative design process is complex and non-linear; C-K helps organize this complexity.
7P	Volcano		It is a symbol of raw and creative intellectual energy, activating mental potentials by expanding the C-space.
8P	Spider on a web		It indicates a creative organization; C-K provides the structure for creating coherent ideas.
9P	Snail		It is a metaphor for the slow but continuous process of creativity; the layered growth of knowledge and concept.
10P	Ocean wave		It is a sign of fluid, variable, and dynamic creativity requiring flexibility in the educational structure.

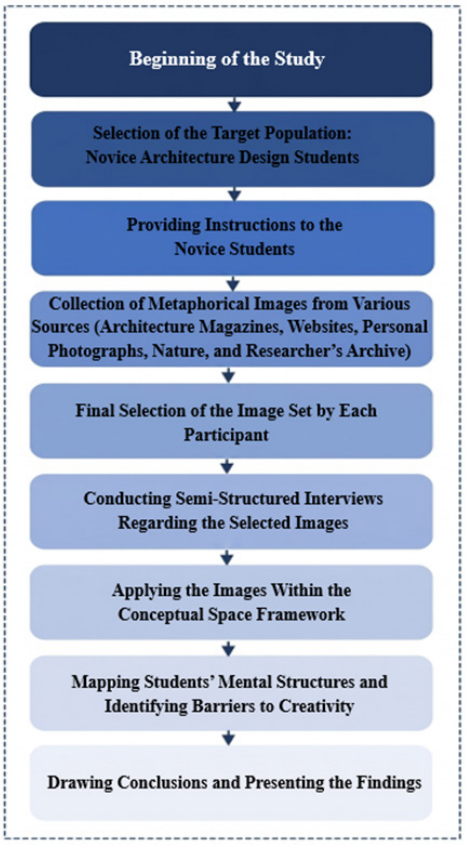


Fig. 2. Executive stages of the study. Source: Authors.

Other categories, such as "complex process" and "gradual growth," require guidance and targeted exercises so students can translate their ideas into practical and innovative pathways.

To quantitatively analyze the importance of each component in the students' creativity process, the number of metaphors in each category was calculated and converted to a percentage. Fig. 3 shows which parts of the students' creative minds are most active and which parts need strengthening. The chart (Fig. 3) shows that students focused most on intellectual freedom and creative energy. Other components, such as divergent looking and gradual growth, despite their importance, received less attention and require targeted educational activities to be strengthened. These results align with C-K theory, as the concept space must be developed in a way that allows students to experience innovative pathways.

- **Analysis of the fixation effect on the creativity process**

The purpose of Table 4 is to identify the type of fixation effect on each student and its impact on creativity. The data were extracted from interviews and metaphor analysis to pinpoint the strengths and weaknesses of each student in the design process. Table 4 shows that the fixation effect varies among different students, and those who selected images associated with limitation and repetition (like the withered flower and the bird in a cage) experience the highest fixation effect. These findings emphasize the importance of targeted education based on C-K theory, because creating a concept space and separating from fixed knowledge can open up creative and innovative pathways for all students.

- **Frequency analysis of components**

To better analyze the data, the components extracted from the students' images were categorized, and their frequency was calculated (Table 5). This table

Table 2. Demographic Characteristics. Source: Authors.

Gender			Age			Education		
Category	Frequency	Percentage	21-30 years	1	12%	Bachelor's	1	4%
Male	3	42%	31-40 years	6	69%	Master's	7	32%
Female	7	57%	40 years+	3	19%	PhD	2	9%

Table 3. Categorization of key components of creativity and design capability. Source: Authors.

Category	Metaphor Examples	Conceptual Interpretation	Ratio of Metaphors to Creativity
Intellectual Freedom	Bird in a cage	Need to break educational limitations	25%
Creative Energy	Volcano	Activatable mental potential	20%
Complex Process	Spiral path	Need for organization in C-K	20%
Divergent Outlook	Eye of a wild animal	Developing non-cliché thinking	20%
Gradual Growth	Snail	Gradual progress in the conceptual space	15%

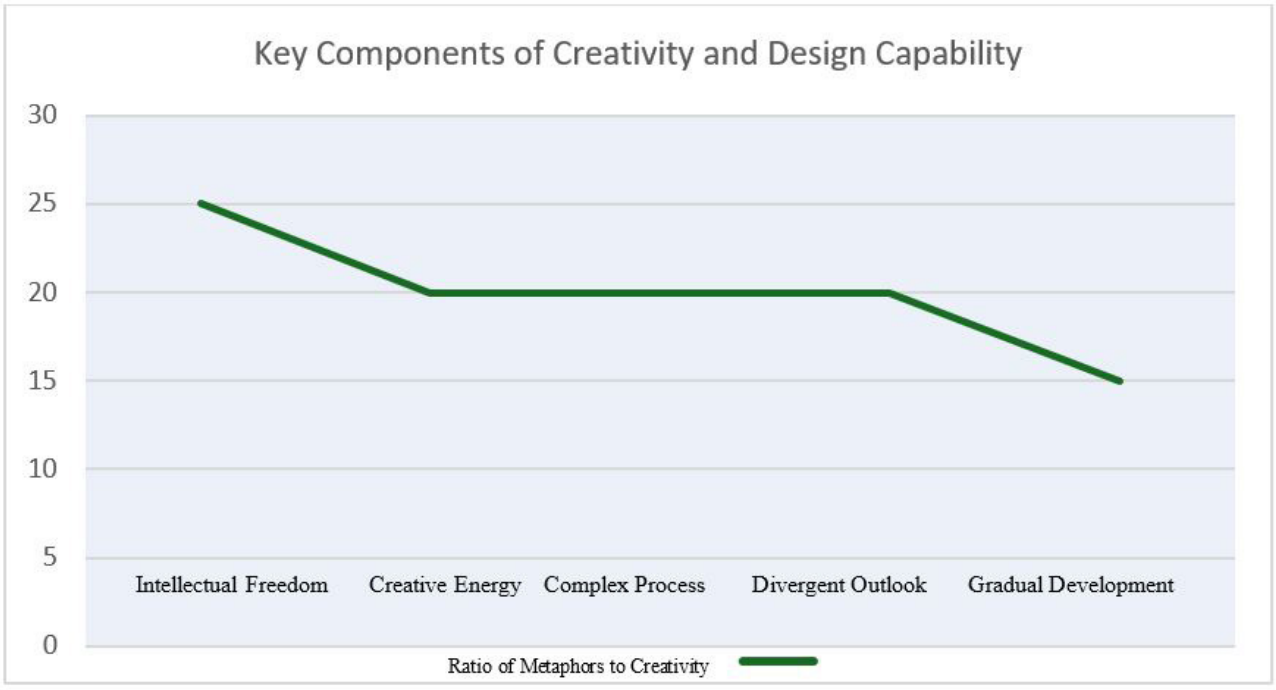


Fig. 3. Ratio of Metaphors to Creativity Components. Source: Authors.

Table 4. Analysis of the fixation effect on the creativity process. Source: Authors.

Novice Code	Fixation Effect	Intensity	Example Metaphor
1P	Low	1	Suspension bridge in the forest
2P	Medium	2	Flowing water in rock
3P	High	3	Withered flower
4P	Low	1	Eye of a wild animal
5P	High	3	Bird in a cage
6P	Medium	2	Spiral path
7P	Low	1	Volcano
8P	Medium	2	Spider on a web
9P	Low	1	Snail
10P	Medium	2	Ocean wave

indicates which components played the greatest role in activating creativity and countering fixation. As seen in Table 5, crossing limitations and mental flexibility were the most important components in activating students' creativity. These findings confirm that implementing the Zaltman technique combined with C-K theory can play an effective role in breaking the fixation effect and enhancing creative design capabilities.

- **Consensus mental map**

The consensus mental map was derived from the process of aggregating, comparing, and interpreting the individual mental maps of the students and, as an analytical framework, enabled the recognition of common components in how creative thinking emerges. This map, in addition to revealing frequently occurring elements, also played a role in explaining the factors effective in reducing the impacts of cognitive fixation and how to overcome it. From this perspective, the resulting pattern could serve as a basis for developing educational strategies, revising design education methods, and designing creative exercises within the context of architectural education. Table 6 presents the results

related to examining the frequency of components extracted from the images generated by the students. Table 6 indicates that the students' focus is on breaking limited patterns and developing the conceptual space. The "exiting fixation" axis has the highest frequency and emphasizes that creative education must create an environment where students can break out of conventional frameworks and generate innovative ideas.

Discussion and conclusion

The findings of this research align with the results of some previous studies in the field of creativity in design education. For example, Kazakçi et al. (2014) showed that using theoretical design frameworks can increase the quality of generated ideas. Furthermore, the results of the study by Sola et al. (2017) regarding the decline in creativity during engineering education correspond with the findings of this research concerning the fixation effect in the architectural education process. In the current study, utilizing the C-K framework and metaphorical activities helped expand the students' conceptual space and created new pathways for ideation.

Data analysis revealed that the metaphors and images selected by the students are not merely descriptive reflections of the design experience, but rather uncover shared cognitive patterns regarding how they confront the design problem. Reviewing the extracted themes indicates that a significant portion of the students faced some form of conceptual limitation or fixation effect in the early stages of design, meaning their initial ideas were mostly formed within the framework of known patterns. However, during the process of extracting metaphors and reflecting on mental images, some students were able to expand the conceptual scope of the problem and create new pathways for ideation. This shows that utilizing the metaphorical approach can act as a tool to break fixed patterns in the design process.

- **Intra-case and inter-case data analysis**

The current study was conducted to investigate the impact of integrating the C-K theoretical framework and the Zaltman metaphor technique on the creativity process and countering cognitive fixation in architecture students.

In the first stage, an intra-case analysis was performed for each participant to independently examine the conceptual structure of the metaphors and selected images. In this stage, the main themes related to each student's design experience were extracted, and the relationships among concepts were identified. The results of this analysis showed that each student attempted to express their mental experience of the design process through a set of metaphors.

In the second stage, an inter-case analysis was conducted to identify common patterns and conceptual differences among the participants. Comparing the extracted themes showed that some metaphors were repeated among several students, indicating similar cognitive experiences when facing the design problem. Conversely, some metaphors represented differing student approaches to expanding the conceptual design space. This comparative analysis enabled the identification of general patterns in how creative ideas are formed among students.

Data analysis demonstrated that simultaneously utilizing the C-K framework and metaphorical images, while activating the ideation process, allows for the cultivation of divergent thinking and the development of the concept space. After extracting the metaphors, the data were categorized based on key components of creativity and design capability. As seen in Table 3, the students' greatest attention was directed toward the components of "intellectual freedom" (25%) and "creative energy" (20%), highlighting the students' need for more opportunities to break out of educational limitations and activate mental potential. Other categories, including "complex process" (20%), "divergent outlook" (20%), and "gradual growth" (15%), indicate that part of creativity requires guidance and targeted exercises to transform ideas into practical and innovative pathways. These results are consistent with C-K theory, as the concept space must be developed in a way that allows students to experience innovative pathways.

Based on the analysis of the fixation effect (Table 4), the intensity of the fixation effect varied among students. 70% of the students (codes 1P, 4P, 7P, 9P) experienced a low fixation effect, while the other 30% (codes 3P and 5P) had a high fixation effect. Metaphorical images like the "withered flower" and "bird in a cage" represented mental limitations caused by fixation, and students who worked under the guidance of the C-K framework were able to distance themselves from a reliance on prior knowledge and generate innovative ideas. These findings emphasize the importance of targeted education and designing creative exercises to reduce the fixation effect.

The frequency analysis of the components extracted from students' images (Table 5) showed that the most important factors in activating creativity were "crossing limitations" at 40% and "mental flexibility" at 30%. "Enhancing divergent thinking" and "mental energy and motivation" accounted for 20% and 10%, respectively. These results indicate that implementing the Zaltman technique alongside the C-K framework plays an effective role in breaking the fixation effect and enhancing creative design capabilities.

The consensus mental map (Table 6) also showed that the "exiting fixation" axis had the highest frequency (70% student participation), followed by developing concepts (60%), activating creativity (50%), divergent thinking (40%), and organizing ideas (30%). These results suggest that students exert their greatest effort to break limitations and develop the conceptual space, and structured, targeted education using the C-K framework can guide these efforts more effectively.

Overall, integrating the C-K framework with the Zaltman metaphor technique enabled students to increase the diversity of ideas, reduce the fixation effect, and strengthen their visualization and divergent thinking abilities. The students' focus on key components such as intellectual freedom, creative energy, and crossing limitations demonstrates that creative architectural education must provide an environment where students can step outside conventional frameworks and experience innovative, non-cliché pathways. The findings emphasize that the simultaneous use of visual stimuli, metaphorical techniques, and the C-K framework can significantly improve the architectural design education process, strengthen creativity, ideation, and innovation skills in students, and prepare them to face complex design challenges.

Research limitations

Despite achieving meaningful results, the current

Table 5. Frequency analysis of components extracted from students' images. Source: Authors.

Component	Number of Students	Percentage
Crossing Limitations	4	40%
Flexibility	3	30%
Enhancing Divergent Thinking	2	20%
Mental Energy and Motivation	1	10%

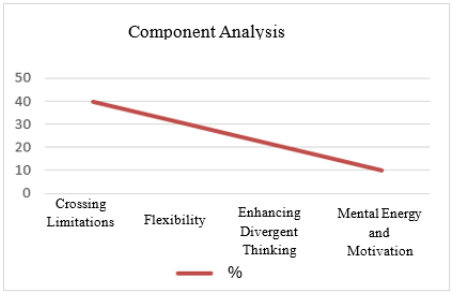


Table 6. Results of the students' consensus mental map. Source: Authors.

Analysis Axis	Key Components	Student Participation Percentage
Exiting Fixation	Suspension bridge, withered flower, bird in a cage	70%
Developing Concepts	Spiral path, flowing water in rock	60%
Activating Creativity	Ocean wave, volcano	50%
Divergent Thinking	Eye of a wild animal	40%
Organizing Ideas	Spider on a web	30%

study was accompanied by certain limitations. Among the limitations of this research was the evaluation of the cognitive fixation effect, which was predominantly based on analyzing interpretive data and the students' mental representations, leaving room for the results to be influenced by the authors' interpretations. Additionally, conducting the study within a specific educational context and examining the short-term stability of the proposed framework's effects can be noted as areas that require further investigation in future supplementary studies.

Suggestions

• Suggestions for improving architectural design education

In addition to explaining the theoretical dimensions of creativity in the design process, the results of this research can have significant practical implications for improving architectural design education.

-Employing the C-K theoretical framework in the design education process can be used as a tool for systematically guiding students' ideation processes. In this approach, instructors can encourage students to gradually expand design concepts and explore diverse ideation pathways by distinguishing between the knowledge space and the concept space.

-Using metaphor-based techniques and mental imagery in the early stages of design can help reduce cognitive fixation. Applying these methods through short exercises in design studios can guide students to discover unexpected connections between concepts and subsequently generate more creative ideas.

-Architectural educational programs can provide a foundation where students experience the process of expanding ideas and rethinking design concepts, rather than focusing solely on the rapid production of a final form, by designing educational activities based on conceptual exploration. Such an approach can gradually strengthen creative thinking skills in students.

-Finally, it is suggested that in the educational policymaking of architecture faculties, more attention should be paid to creative education methods and the development of conceptual thinking in design studios. Combining theoretical design frameworks, such as C-K theory, with creative ideation methods can help elevate the quality of design education and foster the innovative abilities of architecture students.

• Designing structured C-K based education

-Creating an active concept space (C-space) in architectural design classes that encourages students to experience innovative and non-cliché pathways.

-Providing phased exercises that first address breaking limitations, followed by developing and organizing ideas.

• Utilizing images and metaphors in the learning process

-Using the Zaltman technique and visual stimuli related to intellectual freedom, creative energy, and complex design pathways to strengthen divergent thinking.

-Encouraging students to choose personal metaphors and analyze them to connect past experiences and personal knowledge with the design process.

• Reducing cognitive fixation

-Providing exercises that force students out of repetitive and cliché ideas, such as innovative challenge projects or limitation-removal ideas.

-Continuous feedback and group critique sessions to help examine and break fixed patterns.

• Targeted exercises and projects for strengthening less active components

-Activities to strengthen a divergent look and the gradual growth of ideas, which, according to the data analysis, received less attention from students.

• -Using multi-stage projects that compel students to organize ideas and practice precise visualization.

Creating a collaborative and flexible educational environment

-Encouraging group interaction, idea exchange, and discussion regarding visual metaphors and concepts.

-Creating opportunities for trial and error and reflecting personal experiences in the design process to increase student motivation and active participation.

Conflict of interest

No conflict of interest was declared by the authors.

Endnotes

1. In this study, traditional education refers to conventional approaches to architectural design instruction characterized by the dominance of model-based teaching methods, an emphasis on reproducing established design patterns, and the restriction of the design process to predefined frameworks. Such approaches tend to limit creativity and hinder the development of divergent thinking.
2. In this study, divergent thinking is defined as students' ability to generate multiple, diverse, original, and expandable ideas in response to an architectural design problem. Operationally, it is assessed through indicators such as fluency, flexibility, and originality, as reflected in design outcomes and participants' responses.
3. In this study, "overcoming mental constraints" was inferred from students' ability to propose ideas that they initially considered impossible or beyond their own capabilities.
4. In this study, "intellectual freedom" refers to a reduction in self-censorship, an increased willingness to express unconventional ideas, and a departure from conventional frameworks when responding to questions.
5. In this study, creative energy refers to the level of a student's cognitive dynamism and motivational engagement during the design process. It is assessed through the student's ability and willingness to generate multiple ideas, pursue novel concepts, persist in mental exploration, embrace unconventional approaches, and move beyond established patterns of thinking.

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