

Students' Consciousness of their Problem Solving Approaches as a Key to Creativity in Design

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Abstract

Architectural engineering students are constantly dealing with ill-defined and tangled design problems. Many scholars accentuated the importance of creative thinking in tackling such wicked and complex problems. Accordingly, getting engaged in an ill-defined problem solving process requires specific personality traits that are often critical to creativity and innovation in design. In that sense, architectural engineering curricula need to provide various strategies through which such individual skills can be nurtured and developed. The objective of this study is to empirically identify the different patterns of students' approaches in solving problems and the role of group discussions in such a process. The study adopted a qualitative approach, in a live class setup, through a series of workshops to allow for in-depth exploration of the students' problem solving skills and abilities. The intention is to help students in discovering and in being aware of their own way of solving problems and identifying its strengths and weaknesses. This is considered a core and significant step towards the improvement and development of their design thinking skills. The findings of the study have emphasized the positive impact of the cyclical behavior in the creative problem solving process and highlighted the different key issues and lessons emerging from students' consciousness of the mental processes that occurred during this iterative process. Such awareness and consciousness of those emergent issues is expected to encourage conscious design, increase tolerance for ambiguity and improve self-confidence which are believed to dramatically help students in creatively solving ill-defined architectural design problems.

Keywords: problem solving, individual skills, creativity, design thinking, ill-defined problems, design education, architectural design; students' awareness, conscious design, Geneplore model

1 Introduction

In architecture, designers are constantly dealing with wicked, tangled and ill-defined design problems (Buchanan, 1992; Rittel, 1972; Schumacher, 2012). Addressing such complex problems call for creative thinking in order to be able to solve them (Hocking & Vernon, 2017). Getting involved and immersed in an ill-defined and intricate design problem solving process requires an immense cognitive and mental effort, courageous behavior, high tolerance to ambiguity and self-confidence (McAdam & McClelland, 2002; Paletz & Peng, 2009; Reiter-Palmon & Illies, 2004). In that sense, fostering creativity in engineering and design education to enable students to develop as creative designers is quite inevitable (Baillie, 2002; Lau, 2017). Preparing them to be future professional designers necessitates the implementation of practical steps that make creativity an integral part of the architectural curricula (Kowaltowski, Bianchi, & de Paiva, 2010). However, many scholars highlighted the fact that education programs for development of creativity in design education are quite scarce and not provided sufficiently (Baillie, 2002; Bourgeois-Bougrine, Buisine, Vandendriessche, Glaveanu, & Lubart, 2017; Cho, Hong, & Kwang-Soo, 2016).

Therefore, different educational institutions are expected to provide various means and strategies to couple creativity and design education. In an attempt of improving and developing the students' design thinking and cognitive skills, the study aims to investigate the different students' approaches in solving problems through a series of workshops in a course entitled AR221 Scientific Thinking in the Department of Architectural Engineering and Environment Design at the Arab Academy for Science, Technology and Maritime Transport (AASTMT), Cairo, Egypt. This allows for an in-depth exploration of the students' problem solving skills and abilities, identifying their strengths and weaknesses.

The study raises a set of questions that can be summarized as follows:

- Are students aware of their own way of solving problems?
- Can this awareness and consciousness of the mental processes occurring in problem solving help them in the development and improvement of their design thinking skills?

To answer the questions and meet the objective, the study adopted a qualitative approach, in a live class setup, through two different workshops. The study employed a variety of data gathering tactics and methods to allow for data triangulation.

2 Creativity in Problem Solving: A Cognitive Perspective

There are a variety of approaches that tackle creativity from different perspectives. Many scholars addressed this issue and worked on the categorization of the different approaches and paradigms to creativity. Sternberg and Lubart (1999) discussed creativity in terms of six different approaches: mystical, psychoanalytic, pragmatic,

psychometric, cognitive and social-personality approaches. They concluded that another confluence approach, a multidisciplinary one, in which different paradigms and components of creativity can converge is required.

Consequently, a categorization that is based mainly on the work of Taylor (1988), Sternberg and Lubart (1999), and Villalba (2008) was proposed (Cachia, Ferrari, Ala-Mutka, Punie, & Institute for Prospective Technological Studies, 2010). Their categorization included five main approaches: psychometric, psychoanalytic, self-expression and mystical, end-product and cognitive approaches. To them, the cognitive approach embraces phase oriented studies, pragmatic methods and thinking theory. More precisely, it is considered as an umbrella term under which several original paradigms such as pragmatic, cognitive and social-personality approaches are combined.

The perspective proposed by Cachia et al. (2010) in understanding the cognitive approach in a multi-disciplinary nature is quite relevant to this study, which is in an educational context, for various reasons: 1) it addresses creativity as a process and in education, emphasis on the process should be always given a top priority (Cachia et al., 2010); 2) it considers creativity as a skill and accordingly can be developed and nurtured especially in educational and learning environments (Edward de Bono, 2007, 2009); 3) this multi-disciplinary approach is in a sense a step towards implementing different ways and strategies of learning appropriate to each person (Gardner, 1999). Therefore tackling creativity from an inclusive cognitive perspective that involves phase oriented studies, pragmatic methods and thinking theories is the main focus of this study.

There are diverse well known phase oriented studies that deal with the different steps and stages of the creativity process such as the model of Wallas (1926) and the Geneplore model (Finke, Ward, & Smith, 1992). This study focuses on the Geneplore model, which is not linear in nature, because of its relevance to the engineering design cycle and this can help in developing the design thinking skills of architectural engineering students. As implied by its name, the Geneplore model divides the process of creativity into a generation phase and exploration phase (Finke et al., 1992). The model accentuates the dynamic nature of the mental processes that might occur in a back and forth behavior throughout the problem solving process. If the output is non-satisfactory a return to the generative phase is encouraged (Fig. 1). Regarding pragmatic methods, creativity is developed through different techniques and methods, such as those proposed by Edward de Bono, who is a leading figure in this approach. His tools and methods are used to develop lateral thinking skills and to broaden one's perception of a matter (Edward de Bono, 1970, 1991, 2000, 2007). In addition, thinking theories focus on how personality traits and environmental factors are related to creativity (Cachia et al., 2010). Such theories highlight the importance of several personality traits such as self-confidence, attraction to complexity, risk taking, self-efficacy, willingness to overcome obstacles and tolerance for ambiguity to creativity (Gardner, 1999; Sternberg & Lubart, 1999).

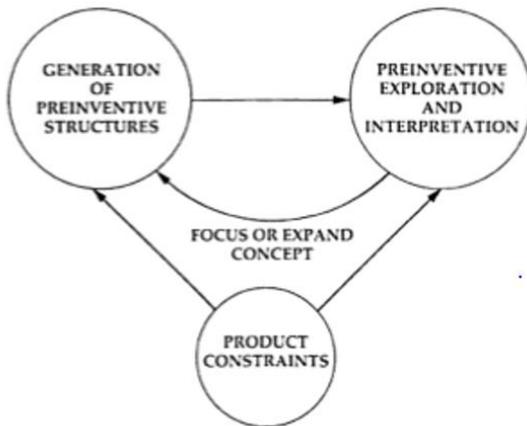


Fig. 1. The basic structure of the Geneplore model (Finke et al., 1992)

Based on the above review of the different schools of thoughts within the inclusive cognitive approach (Cachia et al., 2010), one can conclude the commonalities and overlaps between them. They all focus on the essence of creativity as a process rather than supporting the notion that creativity comes suddenly and unexpectedly. Accordingly, this study tackles creativity in problem solving from this cognitive perspective. It was conducted in a live class setup where students were engaged in different workshops and exercises that are based on pragmatic methods. An in-depth exploration of the students' problem solving skills during the generation, exploration and modification phases was conducted. Reflection and insights of such investigations and its impact on their personality traits were concluded.

3 Methodology

The objective of this study is to identify the different patterns of students' approaches in solving problems and the role of group discussions in such a process. The participants in this study are students who are enrolled in a course entitled AR221 Scientific Thinking¹ in the Department of Architectural Engineering and Environment Design at AASTMT. The intention is to help students in discovering their own way of solving problems and identifying its strength and weakness. This is considered as a significant step towards the improvement and development of their design thinking skills.

3.1 Research Design

The study adopted a qualitative approach in a live class setup to allow for in-depth exploration of the students' problem solving skills and abilities. Such a live setup helps in understanding the phenomenon under investigation in the typical complex and messy

¹ This course, in its current status, has been designed, developed and taught by the author since fall 2008.

setting of a semester with all the normal pressures associated with it (Taborda, Chandrasegaran, Reid, Ramani, & Kisselburgh, 2012). The study relies on the analysis of two different workshops. The data collection draws from different sources such as oral and written students' reflections and insights, the author's observational field notes, photographs, videos, audio recordings and samples of students' work.

3.2 Description of the Context and Workshops

The study was conducted in fall 2019 and 42 students in two different classes, 21 per each, were involved. It focuses on the analysis of two different workshops in which different exercises were conducted. The exercises are inspired from and based on original problems proposed by Edward de Bono (1991).

The first workshop was held on two consecutive sessions with a total duration of four hours. Most of the students were working in pairs constituting 23 groups numbered from 1 till 23. In this exercise, students were required to create abstract compositions according to a set of constraints that increase in complexity from one step to another using six identical block-shaped objects².

The second workshop was held over a two-hour session. Students were working in groups composed of 4 – 5 students, with a total of 10 groups labeled from A to J. In this exercise, students were required, in two different problems³, to place the bottles of water on a flat surface and the distance between each of them should be slightly more than the length of a linear flat element, in this case wooden tongue depressors were used. Using a maximum of four tongue depressors, they should construct a platform on top of the bottles and it ought to be strong enough to support a full plastic bottle of water.

By analyzing the work conducted and the mental processes involved during the problem solving process in the above workshops, the research is expected to answer the following questions:

- What are the different classifications of solutions and patterns of students' approaches in solving problems?
- What are the key issues and lessons emerging from students' consciousness of the mental processes that occurred during the cyclical problem solving process?

4 Analysis and Discussion

During the different workshops and exercises, which were based on pragmatic methods and techniques, multiple Geneplore cycles occurred and in fact one cycle informed the

² Problem 1: arrange the six blocks so that each touches two and only two other blocks; problem 2: arrange the six blocks so that each touches three and only three other blocks; problem 3: arrange the six blocks so that each touches four and only four other blocks; problem 4: arrange the six blocks so that each touches five other; problem 5: arrange the six blocks in the following fashion (one block must touch only one other, one block must touch only two others, one block must touch only three others, one block must touch only four others, one block must touch only five others).

³ First problem in this exercise was to use three bottles where each bottle forms the corner point of a triangle of equal sides; second problem in this exercise was to place four bottles where each bottle is placed at the corner of a square.

other. Encouraging students to alternate between generation and exploration has resulted in a significant improvement in the solutions and alternatives proposed by the students. This is quite consistent with the findings of Finke et al. declaring that “This cycling between the phases of generation and exploration typically occurs when people engage in creative thinking” (Finke et al., 1992, p. 18).

In this qualitative study, there was extensive verbal and visual material, in the form of oral and written students’ reflections and insights, the author’s observational and field notes and samples of students’ work. A classification, sorting and categorization task was conducted to analyze this material in order to understand the reasons behind such a significant improvement in results. During this analysis process, close scrutiny helped in identifying the different categories of solutions and patterns of students’ approaches in solving problems. Moreover, abstracting out assisted in capturing the common recurring ideas and themes which has led to the extraction of different key issues and lessons emerging from students’ consciousness of the mental processes that occurred during this cyclical process.

The following part will discuss those different categories and patterns of problem solving and the emergent lessons highlighted while relating them to the relevant literature and previous studies. The findings of this qualitative study will be supported by quotations, observational notes along with case descriptions selected from the work of students.

4.1 Classification of the Different Students’ Solutions and Alternatives

In digging deep trying to understand what happened during this cyclical problem solving process, different patterns and approaches of solving problems were discovered and solutions can be grouped and classified as follows:

4.1.1. Incorrect Trials Leading to Valid Solutions

It was observed that many students arrived at a valid solution through incorrect trials (or with the help of incorrect trials). Through trial and error, they concluded that it is not a must to change the whole idea, sometimes developing and modifying it leads to the required results. One of the students telling his colleague while looking at the alternative “We do not have to start from scratch, we can modify the existing incorrect solution and try to make it fit the given criteria” and finally they were able to rectify it (Fig. 2). Many students comprehended the vital role of incorrect trials in proposing valid and interesting solutions and how failure can inform success.

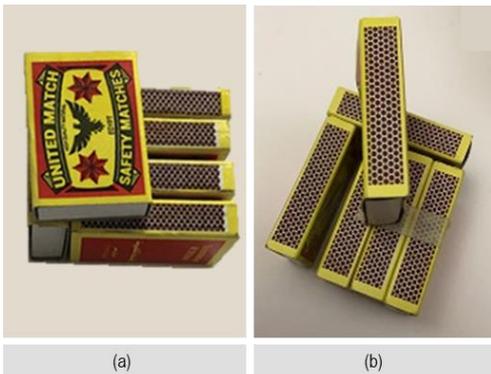
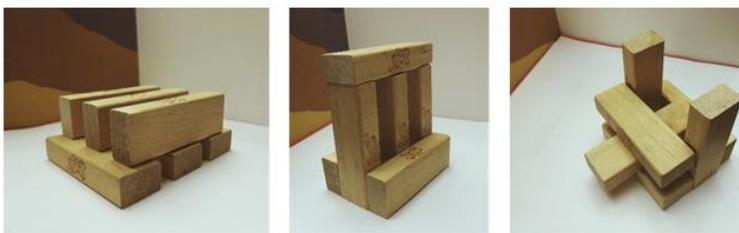


Fig. 2. An example showing (a) an incorrect trial leading to (b) a valid solution by experimenting through subtracting, displacing, flipping and rotating (*workshop one, problem 5, group 13*)

4.1.2. Simple Valid Solutions Turning to Complex Solutions

After arriving at valid solutions that fit the criteria of a given problem, some students who were still provoked to propose more creative alternatives started to dig in more. They tried to explore with different directions, orientations, positions, visual inertia, degrees of stability and surface area. For example, one of the groups presented some horizontal and vertical alternatives and they were even more challenged and tried to merge the horizontal and vertical treatments in addition to changing the stability and visual inertia of the compositions generating more complex solutions (Fig. 3). In another exercise, and through play and discovery, a group initially proposed an alternative in which they were able to lift the weight using the four wooden tongue depressors and placing the bottle with a small surface area, then a much smaller area on the platform (Fig. 4a and 4b). They were provoked and extremely engaged and tried to use only three sticks to lift the weight and they succeeded; surprisingly they decreased the surface area of the weight on the platform again until they were able to balance it (Fig. 4c and 4d). In general, this provocative and generative behavior has resulted in restructuring of the existing patterns and accordingly synthesizing it into new ones creating more complex and interesting alternatives.



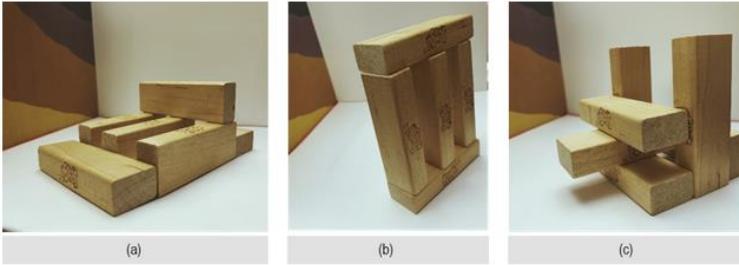


Fig. 3. An example showing simple valid solutions turning to complex solutions through experimenting (a) horizontally, (b) vertically and (c) merging horizontal and vertical solutions to generate new alternatives (*workshop one, problem 2, group 14*)

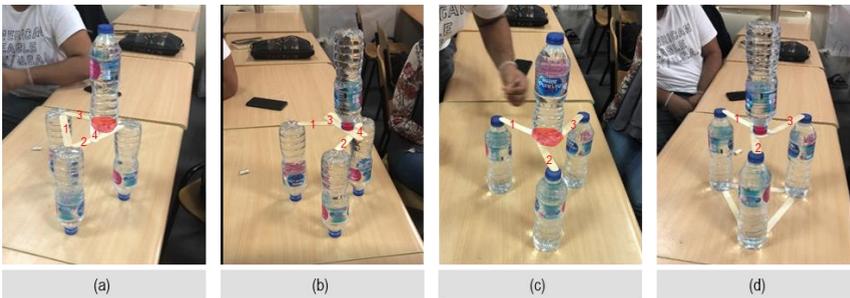


Fig. 4.

Attraction to complexity through lifting the weight on the platform (a) using the four tongue depressors on a small surface area, (b) using the four tongue depressors on a much smaller surface area, (c) using only three tongue depressors on a small surface area and (d) using only three tongue depressors on a much smaller surface area (*workshop two, problem 1, group F*)

4.1.3. Solutions that Meet the Criteria Becoming Solutions that Exceed the Criteria

Some students were able to take the challenge even further than just meeting or satisfying the given constraints or rules. For example, they started to imagine, associate and link their abstract compositions to the surrounding environment (Fig. 5a). Others modified their alternatives trying to re-structure it in order to fulfill another self-imposed criteria (Fig. 5b). Others started to specifically relate and tie to different architectural phenomena, concepts and ideas such as cantilevers, voids and orientation in architecture (Fig. 5c). Furthermore, one of the groups not only associated to architecture by mentioning that the composition resembles a pathway, but also has modified the composition through shifting to enhance the proportions, enclosure, illumination and depth of the space creating a more complicated and innovative solution (Fig. 5d). In addition, some students tested the stability of the proposed platform not only through the given weight, full plastic bottle of water, but also by applying additional weights to the original one (Fig. 6).

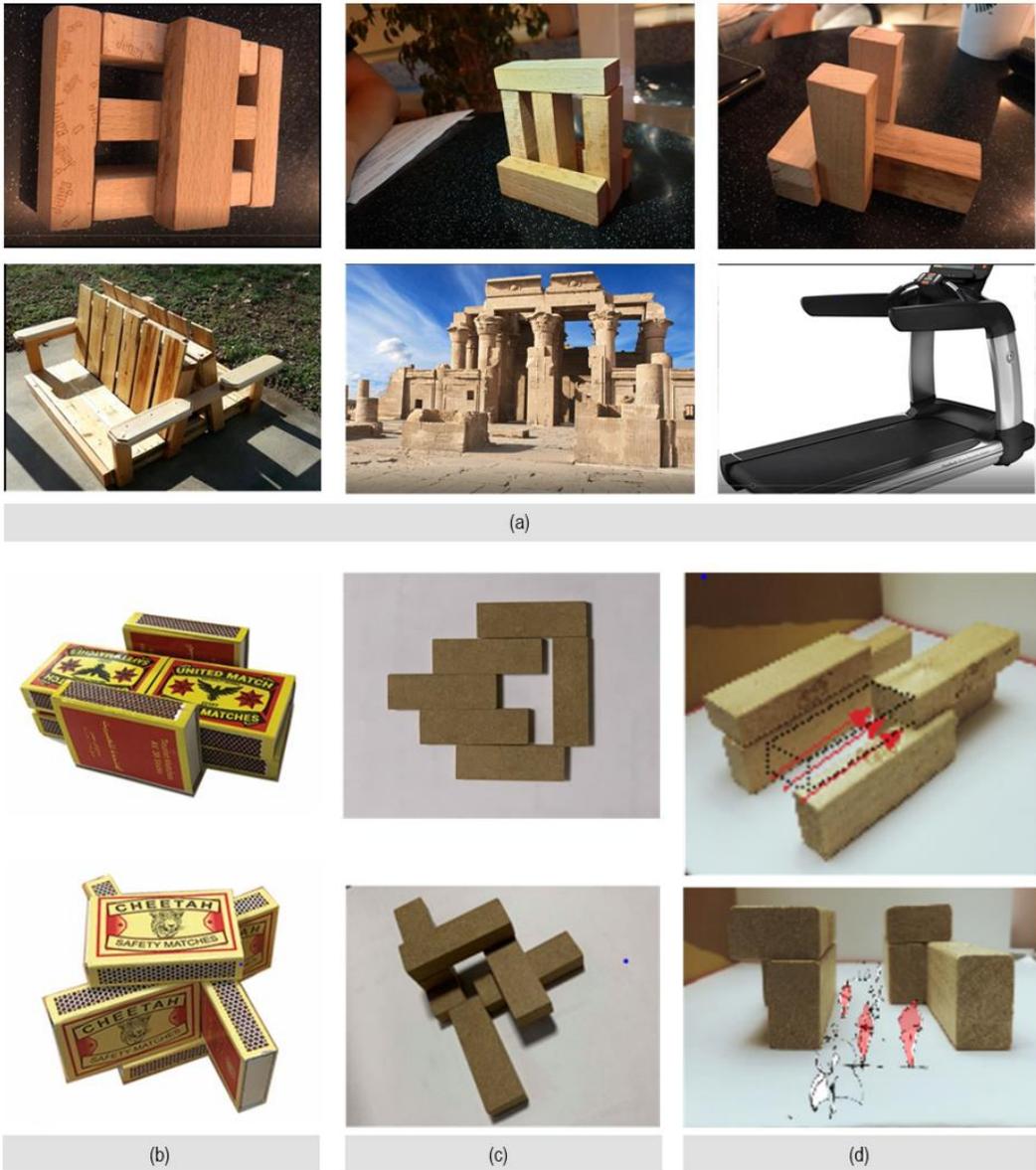


Fig. 5. Sample of students' work taking the challenge beyond the given constrains or rules (a) associating and linking their abstract compositions to the surrounding environment (*workshop one, problem 2 and 3, group 4*), (b) modifying the valid alternative trying to restructure it to generate a composition with a base, body and a cover in addition to meeting the original criteria (*workshop one, problem 3, group 9*), (c) developing a static solution to a dynamic self-supported structure, referring to it

as cantilevered blocks, and imagining it as an architectural composition that is sitting lightly on the ground (*workshop one, problem 1, group 1*) and (d) imagining the abstract composition as a pathway, and accordingly shifting one of the blocks backwards to enhance proportions, enclosure, illumination and depth of the space (*workshop one, problem 1, group 17*)

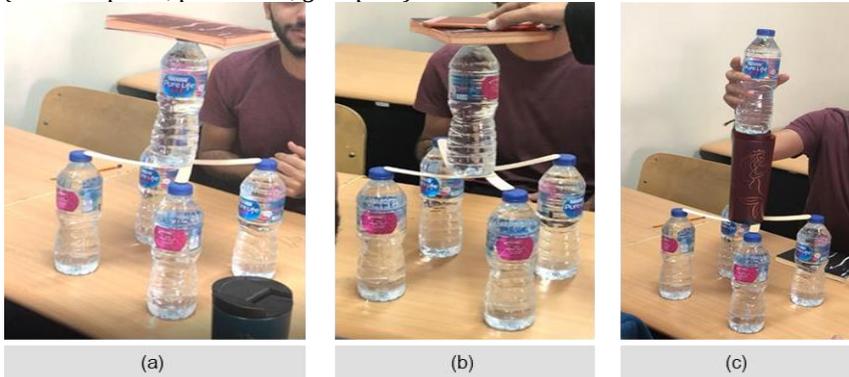


Fig.6. Experimenting and playing with extra weights to test the stability and strength of the platform (a) adding a notebook, (b) adding a notebook and a mobile phone and (c) full car mug in addition to the bottle (*workshop two, problem 2, group H*)

4.2 Key Issues and Lessons Emerging from Students' Consciousness of the Cyclical Problem Solving Process

The analysis revealed four key issues and lessons emerging from students' awareness of the mental processes that happened during the cyclical problem solving process: experimentation and discovery, challenging the obvious, discussion and collaboration and deferring early judgment.

4.2.1. Experimentation and Discovery

Nearly, all the students have valued the importance of experimentation in the creative problem solving process and considered it as an integral part of the process. They understood the critical role that many operational verbs, such as trying, retrying, flipping, shifting, rotating, mixing, merging and integrating, play in proposing innovative solutions. Based on the analysis, many of those operations and experimental approaches done by students, yielded outstanding results. Through experimentation and discovery, they were able to generate, explore, modify, develop, diversify, fine tune and refine their outcomes. Some students were unable to find an alternative that fulfils the given criteria and through trial and error they were able to arrive at valid solutions (Fig. 7). Others were able, through play, to arrive at a solution adopting a sequential manner and based on this they were able to figure out a rule through which an infinite number of alternatives were generated (Fig. 8). Those who were not satisfied with their simple proposals kept trying and experimenting in order to discover new approaches and possibilities. As emphasized by Michalko (1991), a simple or mild change stimulated and provoked an endless number of ideas. This change might be in relational properties such

as orientation, visual inertia, and position (Fig. 9a), or could even be in the nature, material or type of objects used. Change in visual inertia, degree of stability and balance of a composition with an identical arrangement yet a different object was observed, creating an interesting diversity in the proposed solutions (Fig. 9b).

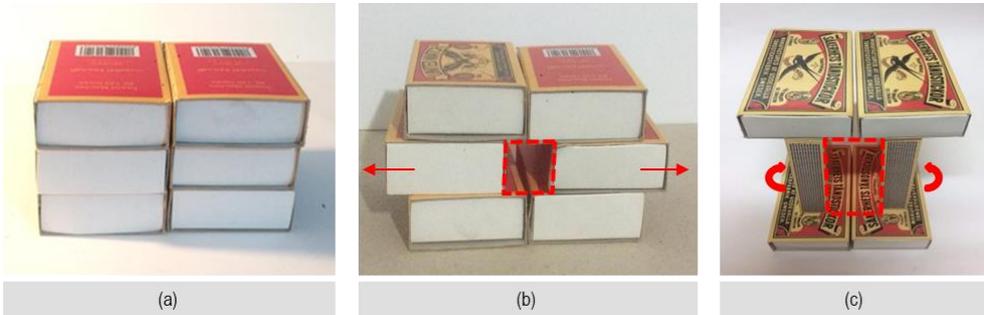


Fig.7. Fixing an (a) incorrect alternative through shifting to (b) create voids generating a valid solution in addition to (c) changing the proportions of the void, through rotating and flipping, creating a new alternative (*workshop one, problem 1, group 11*)

It was observed that play, fun and free investigations were always involved when a better solution was proposed by students. This is consistent with numerous studies arguing that students are deeply engaged in a learning environment that encourages play, discovery and having fun (Carroll & Thomas, 1988; Taborda et al., 2012). For example, one of the groups used different objects to test the strength of the platform. They started with a light object and when they succeeded they placed the given weight showing that they gradually became more confident (Fig. 10). Another group was experimenting and playing with extra weights to further test the stability and strength of the platform. Not only were they using different objects as extra weight to add more complexity to the challenge, but they also used precious objects such as mobile phones showing increased self-confidence and high inclination towards risk taking (Fig. 11).

Adopting a loose attitude, as referred to by Lin (1993), rather than a tight one and a willingness to try and re-try and see a mistake as something positive is greatly important to develop as creative thinkers and designers. Fostering an environment for creative work requires providing a balance between structure and free investigation, encourages play and fun methods and emphasizes the importance of reflection and iteration (Edward de Bono, 1991; Puja Khatri & Sumedha Dutta, 2018).

According to Cross (1999), design is opportunistic and exploratory in nature and cannot be predicted or anticipated in advance. Thus, a creative designer needs to think about what might lie ahead, discover something new instead of recycle something that he/she already knows. This confirms the importance of experimentation and discovery to creative problem solving in design and how it helps in improving self-confidence, encourages risk taking and enhances tolerance for ambiguity and they are all critical to creativity in design (Cross, 1999).



Fig.8. Figuring out a general rule (a) proceeding in a sequential manner, (b) and accordingly an infinite number of alternatives was generated (*workshop one, problem 5, group 18*)

4.2.2. Challenging the obvious

It was found that raising questions was extremely helpful in the problem solving process. According to Michalko (1991), questions stretch one's eyes wide open. Questions helped in viewing the challenges from different perspectives, thus introducing new possibilities. This was either achieved through an insight which was quite rare, or mainly through critically revisiting and analyzing their proposed alternatives. Some students started to group and classify their proposals highlighting similarities and accordingly concluding the self-imposed constraints that they were imprisoned by and consciously started to challenge them. For example, they started wondering does it necessarily have to be a loop! Why not vertical? Should it be only orthogonal? Why symmetrical? In addition to many other similar questions (Fig. 12a, 12b and 12c). In other cases, students tried to analyze their incorrect trials, what didn't they try, challenging how else and what else is missing (Fig. 12d).

This curious and skeptical behavior allowed students to reverse the different conventional assumptions that they have subconsciously imposed on themselves, and this in turn, has helped them not only in generating and developing their proposals but also in proposing unique ideas and breakthroughs. Based on this, most of the students became more attracted to complexity, patient even if they do not know the answer yet and more willing to overcome any obstacles. They, as emphasized by Edward de bono

(1970), started to use provocative manners instead of simple ones and believed that no matter how good something is, there is always a potential of doing it better.

As a reflection, being skeptical and challenging the obvious along with how this positively affects the tolerance to ambiguity and willingness to overcome problems is very important in addressing architectural design problems. The design process is an indeterminist one, as referred to by Goldschmidt (1997), which is characterized by uncertainty and ambiguity (Cross, 1999) and thus requires such skills. Preconceptions and prejudgments are issues that need to be widely addressed in design education (Kowaltowski et al., 2010). Liberation from conventional assumptions and preconceptions help designers to expand their possibilities. Although this is quite overwhelming for designers, yet this leaves many options open for as long as possible and that is a merit that usually leads to creative and successful designs.

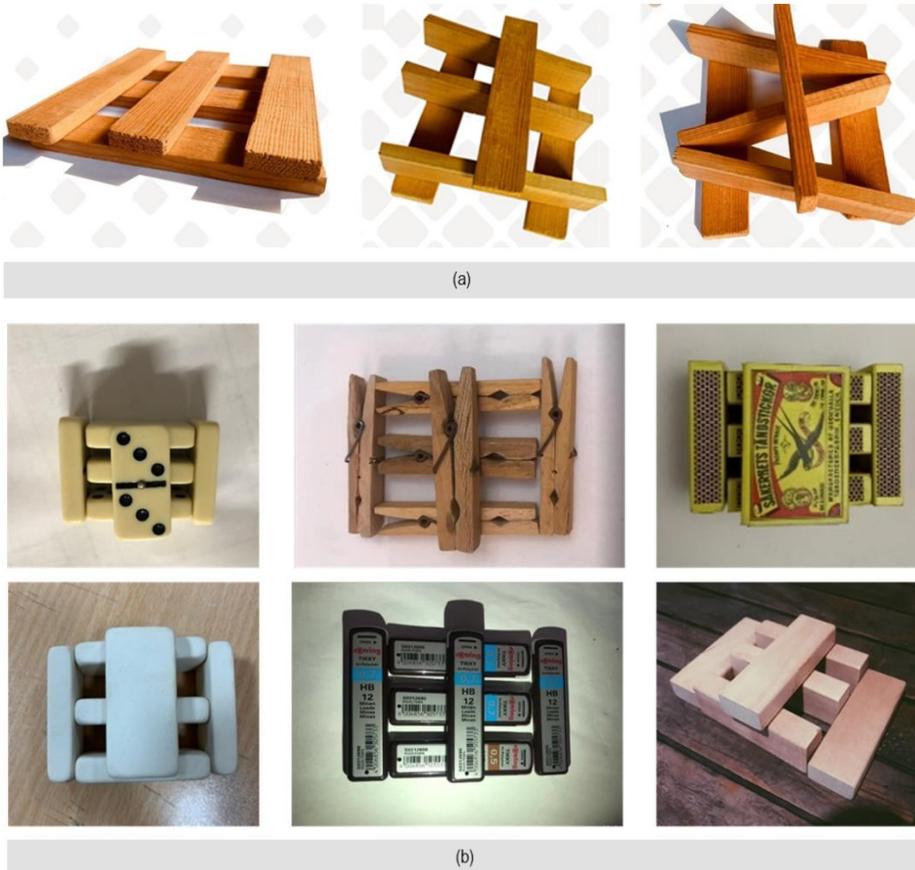


Fig.9. Simple change stimulating and provoking new ideas (a) change in position, visual inertia and orientation leading to more dynamic alternatives (*workshop one, problem 2, group 15*) (b) experimenting and playing with different objects and observing the change in

visual inertia, degree of stability and balance of the compositions (*workshop one, problem 5, group 5*)

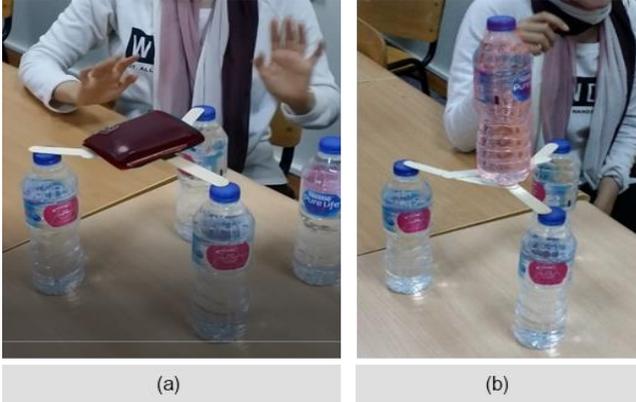


Fig.10. Testing the stability and strength of the platform (a) first using a light object (wallet) (b) using the given weight (bottle) showing gradual increase in self-confidence (*workshop two, problem 1, group C*)

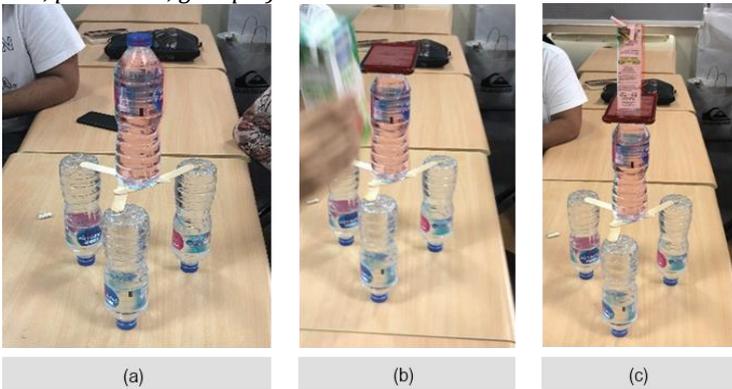


Fig.11. Testing the stability and strength of the platform (a) using only the given weight (bottle), (b) using the given weight (bottle) and a mobile phone, (c) using the given weight (bottle), a mobile phone and on top of it, a small juice box showing increased self-confidence and high inclination towards risk taking (*workshop two, problem 1, group F*)

4.2.3. Discussion and Collaboration

Based on the students' reflections and the author's observations, collaboration, discussion and free-wheeling were very useful and helped many students to arrive at their solutions or even develop them. While working in pairs, during the first workshop, several groups have highlighted the importance of discussion in the problem solving process. One of the students mentioned that the tinkering of his partner to the proposals that he offered was extremely inspiring. He declared that it was beneficial to both of them as mingling each other solutions usually helped them in proposing a valid solution and in developing it to more interesting and unique alternatives

Others mentioned how thinking out loud, talking about ideas to others was important. Listening to insights that emerge from the group rather than trying to push one's own idea, as emphasized by Sawyer (2006), was the spark that led to numerous alternatives and solutions. For example, while trying to lift the weight on the platform and after nearly losing hope, one of the group members who was meticulously observing the trials yelled "Let us weave the sticks" and this was it (Fig. 13). Another group highlighted how discussion and collaboration has helped them in taking the challenge even further and applying heavier objects to the platform instead of only the bottle and when showed stability and strength; they became more confident and took higher risks and were driven to more complex challenges.

In that sense, collaboration and discussion are assets that significantly helps in generating genuine and new ideas which lies at the heart of any design discipline. Listening, talking, observing and accordingly developing solutions constantly leads to better results. Scientists, designers and professionals in all fields reported that their most innovative ideas and substantial results emerged from collaborations (John-Steiner, 2006).

4.2.4. Defer and Postpone Early Judgment

During those workshops and exercises, students developed a deeper understanding of how early and quick judgement specifically during the generation phase might deprive them of formulating a unique and creative solution. In fact, it is impossible to be curious and judgmental at the same time. They reflected that such an early assessment, especially within a group, that an idea does not work, negatively affected their level of engagement and suppressed their energy, spirit and contribution. In the second workshop, one of the groups arranged the sticks in a peripheral manner trying to lift the given weight and one of them quickly decided that this is impossible and the whole group got trapped, frustrated and lost the momentum for some time unable to propose other alternatives (Fig. 14a). On the contrary, another group reached the same point and they kept trying even if it looks impossible until they were able to lift the bottle using the sticks arranged only in a peripheral manner by placing the bottle horizontally and it worked (Fig. 14 b). Not only did they achieve this alternative, but they were also able to challenge themselves more and more presenting better and more complex alternatives, just because they deferred early judgement and had high tolerance to uncertainty.

Those findings are in accordance with other previous studies. For Puja Khatri & Sumedha Dutta (2018), a stress free or a non-judgmental environment helps students to express their ideas freely and this in turn opens the learning environment to new thoughts and opportunities. Furthermore, in a group work or brainstorming session, success is related to two main principles one of which is deferring judgement (A.F. Osborn, 1963) and allowing the creative current to flow. Inevitably, this is very important in proposing solutions to ill-defined and tangled design problems.



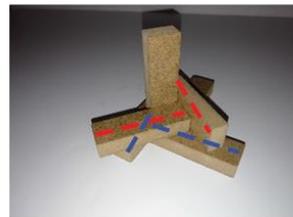
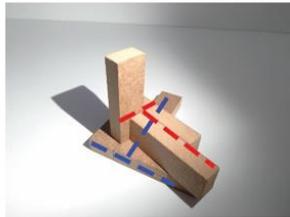
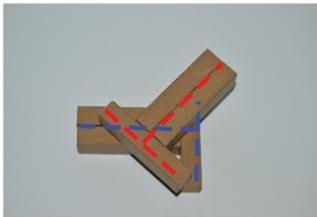
(a)



(b)



(c)



(d)

Fig.12. Challenging the conventional self-imposed constraints and assumptions by wondering (a) does it have to be a loop? (*workshop one, problem 1, group 7*), (b) does it have to be one level? (*workshop one, problem 1, group 9*), (c) does it have to be symmetrical? (*workshop one, problem 3, group 15*) and (d) can a diagonal relationship help in solving the problem? (*workshop one, problem 4, group 12*)



Fig.13. Collaboration and discussion to lift the weight (a) as one of the members yelled “let us weave the sticks”, (b) and they did (*workshop two, problem 1, group B*)

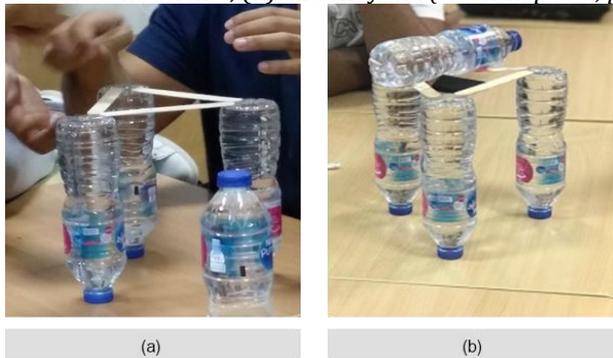


Fig.14. Deferring and postponing judgement as a key issue in creative problem solving (a) quickly judging that it is impossible to lift the weight with sticks arranged only in a peripheral manner (*workshop two, problem 1, group D*), (b) another group lifting the weight using the sticks arranged only in a peripheral manner by placing the bottle horizontally (*workshop two, problem 1, group F*)

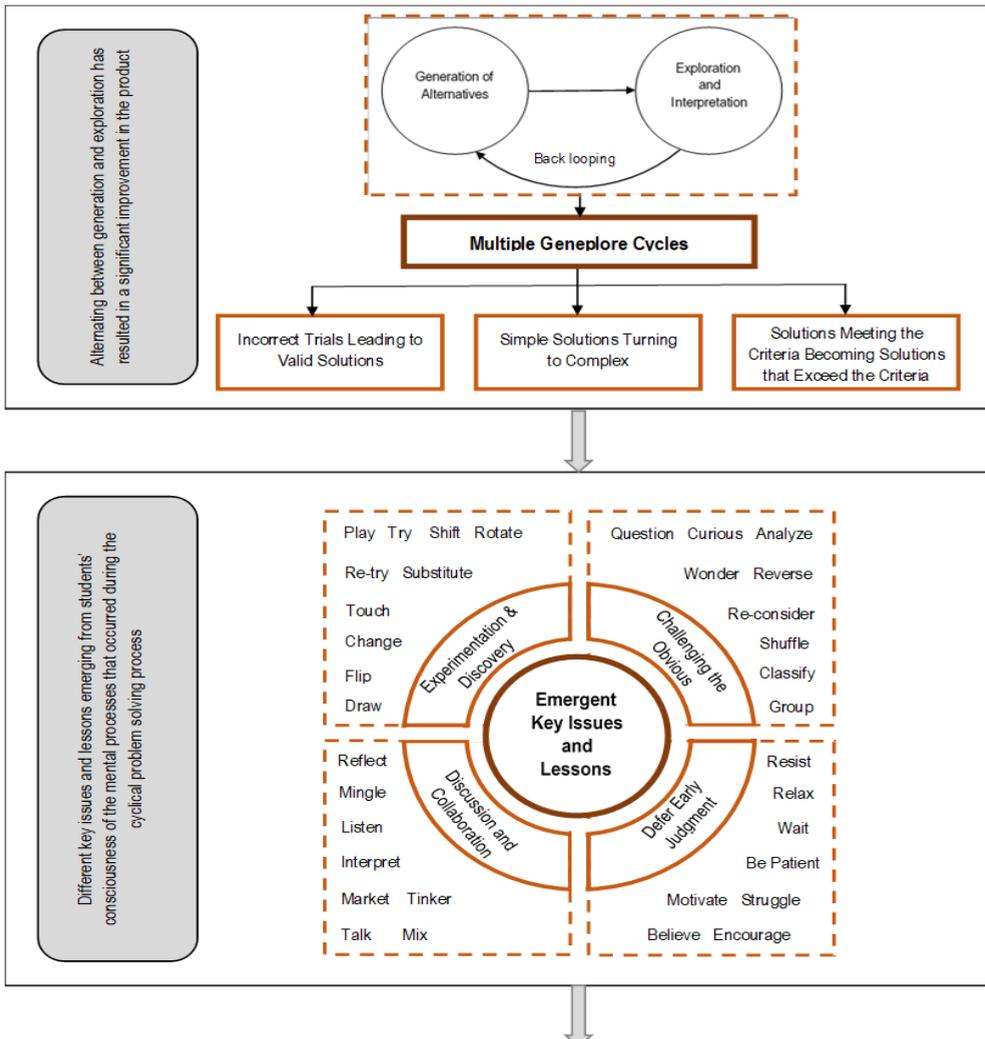
Conclusion

This paper discussed the importance of addressing creativity, specifically in architectural design education, from a cognitive perspective. It aimed at helping students in discovering their own way of solving problems and identifying its strengths and weaknesses. This stems from a belief that such awareness is considered as a significant step towards the improvement and development of their design thinking skills. The findings of the study, as summarized (Fig. 15)., have emphasized the positive impact of the cyclical behavior in the creative problem solving process and highlighted the different key issues and lessons emerging from students’ consciousness of the mental processes that occurred during the problem solving process.

The iterative alternating nature between generation and exploration has resulted in a significant improvement in the product leading to more complex, creative and innovative solutions. Students empirically understood the importance of

experimentation, play and discovery and its role in the creative problem solving process. They experienced how challenging the obvious offered more opportunities and provided new perspectives and insights to the situation. Furthermore, they witnessed and appreciated the important and vital role of collaboration, discussion and deferring judgement in developing, modifying and refining their solutions.

Based on the above analysis and discussion, the awareness and consciousness of those emergent lessons and of the cyclical nature of the creative problem solving process have assisted in developing and nurturing different personality traits. Students' self-confidence, inclination toward risk taking and tolerance for ambiguity have shown improvement and were observed blossoming throughout the process. Such traits are often critical to creativity and innovation in design.



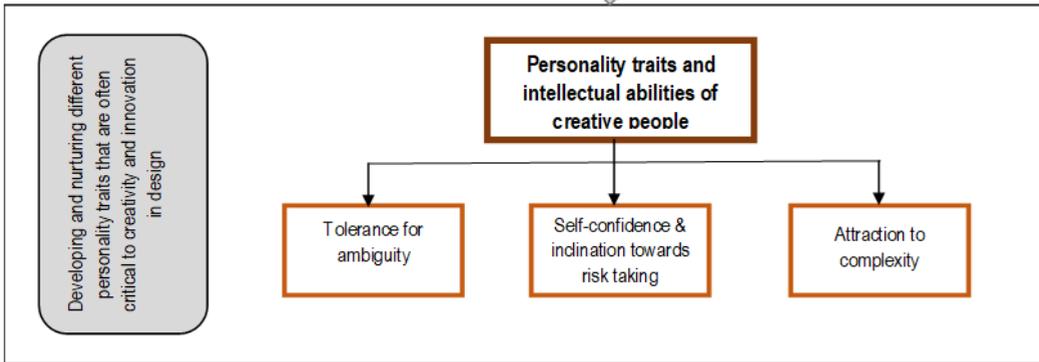


Fig.15. Summary of the core ideas and findings of the study

In conclusion, the findings of the study are expected to encourage conscious design and help students in creatively addressing ill-defined and tangled architectural design problems. Future research could extend the work presented here by exploring further strategies and approaches that couple creativity and architectural design education. More specifically, we need to encourage practical initiatives, in the educational agendas, which work on nurturing and developing the different individual skills and personality traits that often characterize creative and successful designers.

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