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"Thinking Out of the Box" from Out of the Box! Increasing the Dimension of "Starting Point" Case Study: Architecture Students

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Abstract

To start a design process with plan and section in 2D environment (pen and paper) will exclude thousands of possibilities, which the designer will never be able to consider them. The 2D designer will never touch upon the rich world of complexity. Starting the design from higher dimension is the solution to get rid of old conventional designing methods. Adding extra dimension to the "starting point" is applying CAD (computer aided architectural design) software not to extrude the 2D lines, but thinking from a higher dimension. Now thinking out of the box from out of the box becomes possible. To prove the hypothesis, authors decided to conduct an experiment and asked a group of architecture students to design a same architectural task with different dimensions. First the conventional pen and paper in 2D and the second time applying 3D environment interface of their own choice for the same task. The jury of experts concluded that students were more creative when they chose a 3D interface (higher dimension).

Keywords

Creativity, Thinking Out of the Box, Design, Dimension, Pedagogy

1. Introduction

"Thinking outside the box" is more than just a business cliché. It is a metaphor that means to think differently, unconventionally or from a new perspective. This phrase often refers to creativity and creative thinking. A sim-

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plified analogy is "the box", in the commonly used phrase "thinking outside the box", where the word "inside the box" is analogous with the current, conventional methods. Creative thinking acknowledges and rejects the accepted paradigm to come up with new ideas.

Human's creative potential spearheads the human civilization. In fact, progress at every aspect of our lives crucially depends on our creativity. Emphasizing the role of creativity in design even more than other disciplines pushes one to acknowledge the understanding of creativity as a key role player in Architecture. Furthermore by identifying the basic principles of our ingenuity/creativity, researchers might be able to enhance these abilities in future.

But how can we define creativity? Though creativity is the hallmark of human cognition, and therefore a topic of enormous scientific importance, yet not a single definition of creativity exists that is universally accepted by creativity researchers, and the scenario hasn't changed much in the last fifty years (Runco, 2004; Taylor & Barron, 1963). Nevertheless, any creative output (be it an idea, product, or performance) should have, at least, three characteristics: novelty (it is original), usefulness (it is functional and adaptive), and surprising (it is non-obvious, therefore eliciting an aesthetical or affective response) (Simonton, 1999).

The current study suggests new methods for starting a design procedure. It encourages the designers to ignore conventional 2D approaches and apply 3D computer interfaces for early architectural sketches. The paper has two different theoretical sections: talking about creativity and how to reach to creative ideas in the first section and differences between "flatland" and "spaceland" in the second sections. In the third section we bridged between two previous parts and created our hypothesis: does starting a design from a higher dimension helps us to be more creative? To prove the hypothesis, a group of architectural students have been asked to perform one architectural task with two different methods. First, they start a design with pen and paper and the next time, they use a 3D environment. Since judgment of creativity is quite subjective, a group of experts in architecture (University professors) have been considered as a jury and they subjectively did the evaluation. The results, analysis and comparisons are coming afterwards.

2. Part One: Where Do Creative Ideas Come From?

As mentioned earlier, a necessary condition of creativity is novelty, but how can we get new ideas? In his book "The AHA! Moment" David Jones takes a bold stance by claiming that we cannot have a truly new idea, the best we can do is to make combinations of different ideas already known to us (Jones, 2012). Therefore one needs a vast subconscious mass of remembered data in order to increase the likelihood of combination of ideas.

Jones' theory of creativity is based on a three-tiered model of human mental structure (**Figure 1**). The top level is the Observer-Reasoner, the conscious part of our mind that is involved with planning, execution and action. It is also involved with reasoning, argument and conscious deliberation. The mid-level is the Censor, the subconscious part that houses our implicit knowledge (e.g., procedural skills, linguistic skills). It allows rapid access of stored knowledge or information, and also protects the Observer-Reasoner from constant perturbations. The lowermost level is the unconscious mind; the creative part of it is termed as the Random-Idea-Generator (RIG) that combines randomly, without any rule/supervision, ideas or information stored in the unconscious and preconscious mind. Due to the inherent randomness in the combinatorial process, most of the RIG ideas are

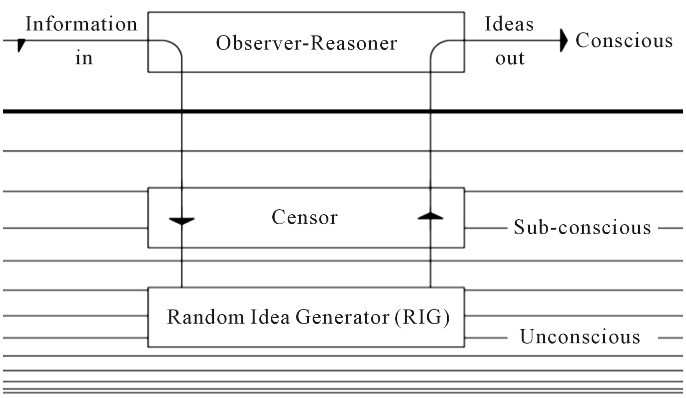


Figure 1. The model of human mental structure after Jones (2012).

wrong or not functionally useful and therefore blocked by the Censor before it could reach the uppermost conscious level, the Reason-Observer. If a creative RIG idea manages to pass the Censor and finally reaches the conscious level, it is likely to be perceived as a flash of sudden insight, known as Aha!

So far importance of creativity and how to reach to creative ideas have been explored. Now we try to explain methods to expand the unconscious mass of data and feed it differently.

3. Part Two: Flatland vs. Spaceland

"Thinking outside the box" starts well before we're "boxed in". That is, well before we confront a design task and start forcing it into a familiar "box": Using Pen and Paper to start a design! Kas Oosterhuis denotes it in his book "Toward a new kind of building" as: inclusion and exclusion (Oosterhuis, 2011). To start a design process with plan and section in an exclusive approach is so poor. It excludes thousands of possibilities, and so the designer will never be able to consider these possibilities. The Flatland-based designer will never touch upon the rich world of complexity. Space-landers can observe the flat-landers without any problem and flat-landers can see line-landers and line-landers can easily internalize the life of point-landers (Oosterhuis, 2011). Starting with a point cloud is a first solution to get rid of old conventional methods and aiming for inclusion (**Figure 2**, **Figure 3**).

Oosterhuis (2011) defines his approach and definition of the point cloud in this way:

> *My personal design universe consists of an interacting population of groups of points in space, wirelessly connected by force fields that are aware of themselves, communicating with their immediate neighbours… My design universe includes interacting point clouds, in which each point behaves as if it is in the centre of the world, even though it is just "somewhere", as our Earth is just somewhere in the Milky way… Each point is an actor*; *always busy measuring and adjusting its position in relation to its peers. Each point is an actuator, triggering the execution of its internal program. Each point is a receiver, processor and a sender in one. Each point of my personal design point cloud displays behaviour, it has character and style. Each point of the point cloud is a microscopic instrument to be played, a game to be unfolded* (**Figure 4**).

Figure 2. Conventional 2D interface, pen and paper.

Figure 3. 3D interface, point cloud.

Oosterhuis implement this approach in real practice. He explains the procedure of his design for the saltwater pavilion: "The saltwater pavilion has evolved from the very beginning of the design process as a three-dimensional computer model. We kneaded, stretched, bent, rescaled, morphed, styled and polished. We no longer accept the domination of platonic volumes, the simplistic geometry of cube, sphere, cylinder and cone as the basic elements of architecture; that resolution is much too low. Our computers allow us to command millions of coordinates describing far more complex geometries" (**Figure 5**) (http://vaa.onl/projects/salt-water-pavilion).

Adding extra dimension to the "starting point" is the point. Starting with a cloud of points floating in endless space and establishing a behavioural relation between those points as birds in the swarm is a proper method (**Figure 6**). Implementing a point cloud in a 2d interface helps a lot, even though it is still confined. Starting to manipulate a point cloud in an immersive 3d virtual environment is starting from a progressive point, since it is already out of the box. Now thinking out of the box from out of the box becomes possible. Experiments in this scope of action have already been started, as mentioned before, this is an on-going project.

4. Experiment

The experiment has been held in Architecture faculty of Shahid Rajayee University in Tehran/Iran. The chosen group were on the last year of Bachelors studies, included 18 students, 3 male and 15 female (**Figure 7**).

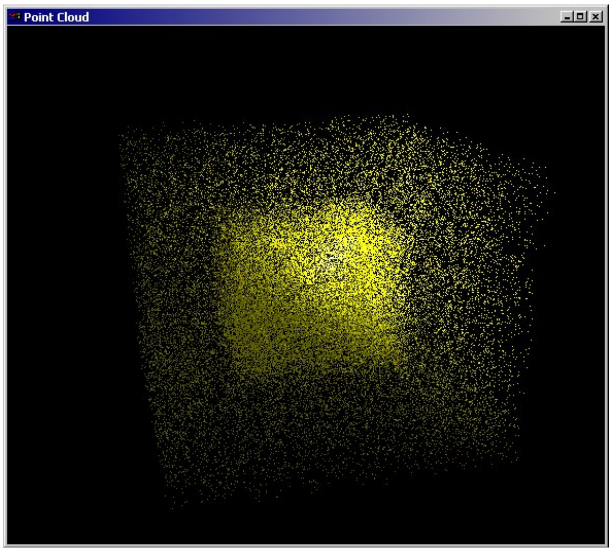


Figure 4. Point cloud.

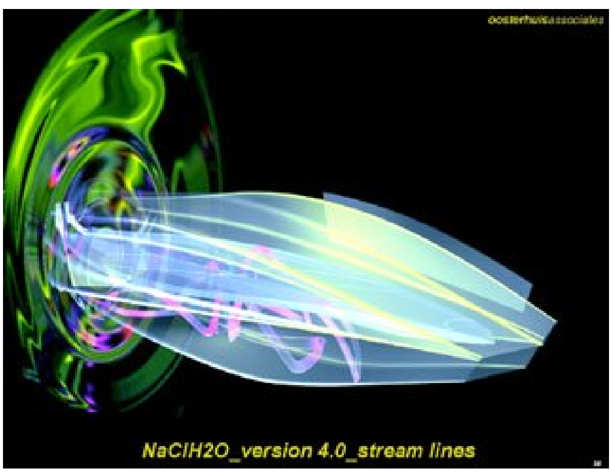


Figure 5. Saltwater pavilion by ONL.

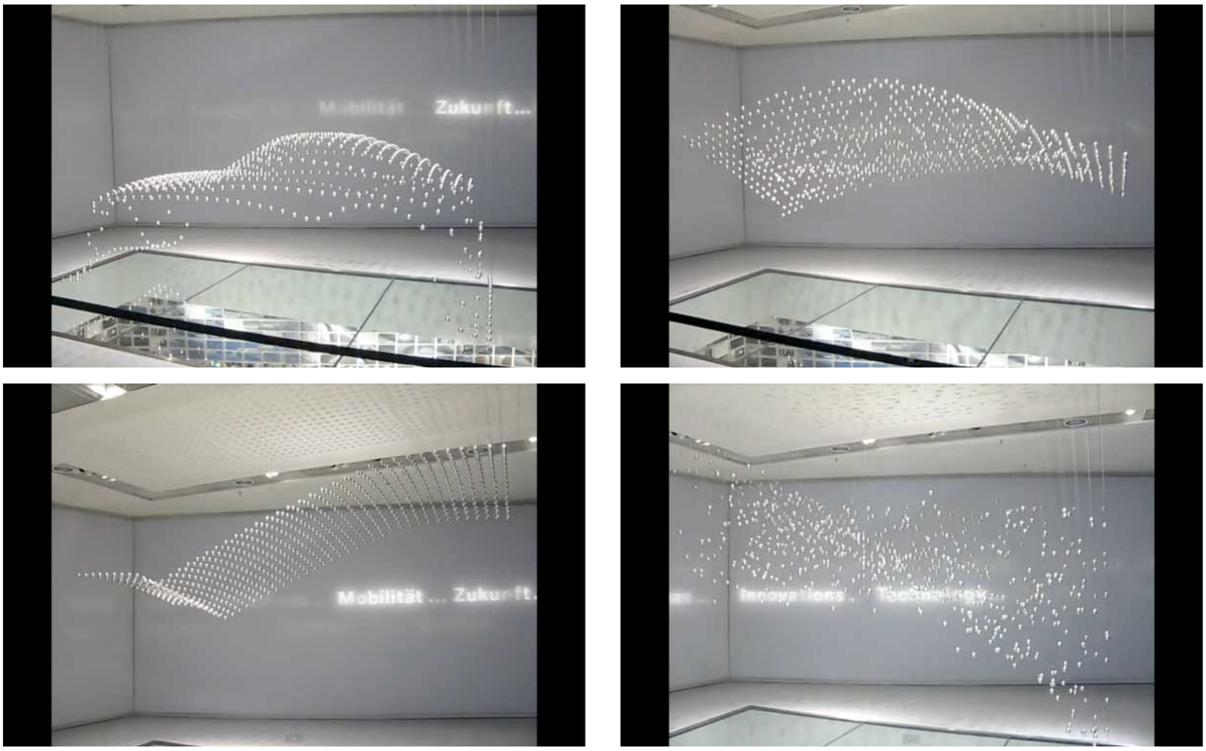


Figure 6. Kinetic sculpture, BMW Museum Munich 2008.

Figure 7. Students while doing the experiment.

5. Instruction

The experiment started with a small presentation on what is the criterion for creativity evaluation. The summary of the presentation is as follow: In architecture the designer deals with many parameters including:

- Find an innovative form,
- Fit in the context,
- Respect the user and their culture,
- Find a better material,
- Find a better detail,
- Solve ecological aspects,
- Optimize the building and make it sustainable,
- Etc.

If the architect can solve any of aforementioned parameters in an innovative way, then the project is a creative one. That is why the creativity of Tadao Ando for instance is different from Zaha Hadid. For the sake of this experiment, if the creativity parameters would be too much, the evaluation was almost impossible, thus for obtaining reliable results at the end of the experiment, the students have been asked to focus only on an innovative form (form-finding) and ignore other architectural parameters for now.

The task was to design a mall around 10,000 m^2, free of any confining regulations. They encouraged not focusing too much on the structural, mechanical and any other technical issue. They asked to be as innovative as possible and they were free to design any double curve, blobby shapes, Euclidean/non Euclidean geometry, etc.

The students have been asked to design once with pan and paper and start design form 2D and afterwards start again using a 3D interface. In the morning session student started to design with pen and paper, however since students had a lot of problem with sketching abilities they couldn't finish the experiment in the designated time or even tend to choose simple geometry to have the possibility of sketching them (**Figure 8**). In the afternoon session, students started to design in a 3D environment.

They were free to choose their 3D software. 39% of students chose Sketch up, 27% of them chose 3D max and 33% did with Autodesk Revit. There was a semi-structured interview at the end of experiment to capture feedback from the participants.

6. Judgment Criterion

In discussions about the quality of a design and of a designer, the concept of creativity is a dominant factor. Ignoring the functionality criterion, the result of this design activity is expected to be original and adding value to the existing world of design. In design awards, and in the field of architecture, creativity assessment relies on human judgments. This article raises the question of whether creativity in architecture design can be judged in a valid and reliable way or not? There exists enormous amount of research in the last decades highlighting the lack of objective methods of evaluation. One reason for this lack is that the need for objectivity by formalizing the measurement leads to a reduction of the features that are quantifiable (Hofstee, 1985). Features that are related to the subjective decisions of the designer, on the whole, be neglected. Another possible reason is that, such concepts as creativity and quality have, according to Hofstee, an emergent character; that is, they are de

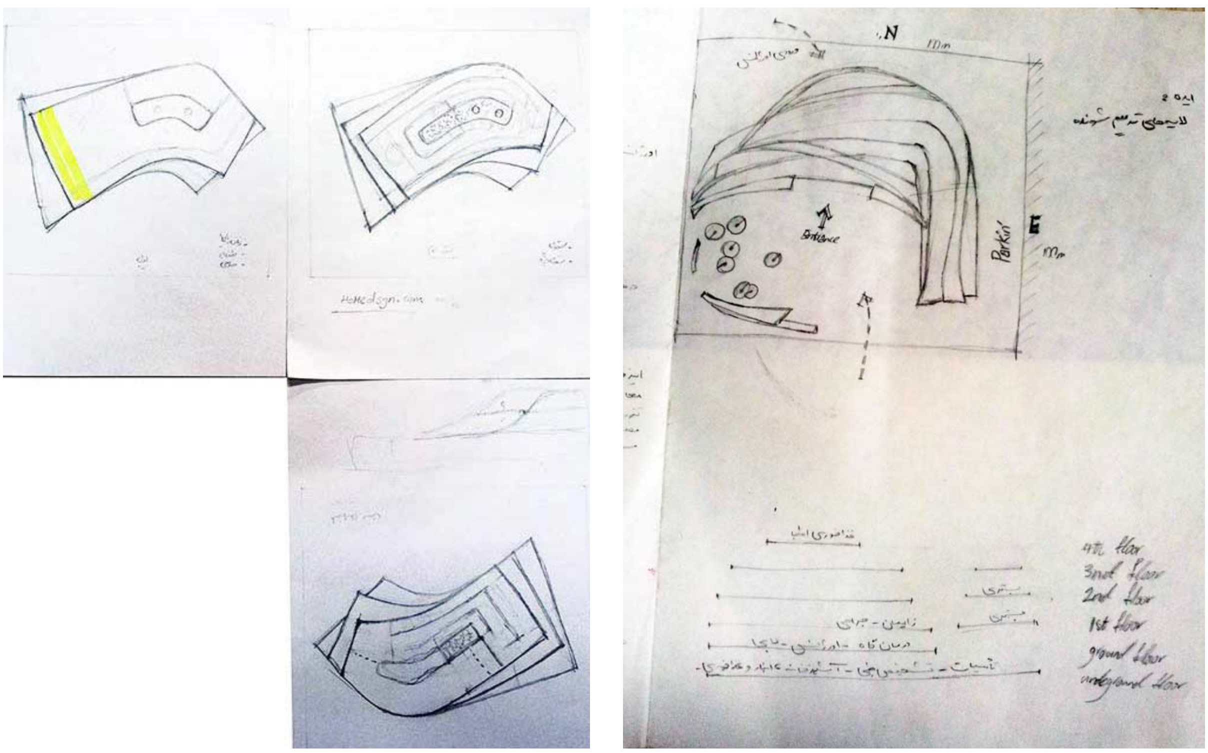


Figure 8. Some of the sketches of students.

fined again and again on the basis of new creations, so that there is no possibility for previous programming. Only a human judge can make estimates of the originality of a product. The fact that there would be mistakes in the decisions is not sufficed to kick the judge out of the system. When estimating the creativity of an architectural design we have to rely on human judgment. In all studies thus far the question has been how to overcome subjectivity within these assessments.

7. Reliability and Validity

Most creativity assessment studies, relying on human judgment, have been performed in the domain of art, and only a few in design (Amabile, 1983; Ward & Cox, 1974). The results of the art studies show considerable variation in inter-rater reliability based on correlations between judges (Christiaans, 2002). Because they are at different levels of subjectivity, the question is whether artwork judgment can be compared with design work judgment. The design of products always builds on previous designs and on the archetype of the designed device (Christiaans, 2002). Ensuring that the functionality of the product is recognized by the user often takes precedence over aesthetic values. Therefore, objective judgments would seem to be more possible in design work than in artwork. However, although the judging of designs is daily practice in real life, playing an important role in decisions about production and in the awarding of prizes, no controlled experiments have been found to confirm this assumption. The reliability of intersubjective measurement seems also to depend on the expertise of the judges.

In the field of art, professionals or trained observers are presumed to be more reliable than naive observers (Hekkert & Van Wieringen, 1996; Runco, Mccarthy, & Svenson, 1994). Amabile (1982) argued that "appropriate" (familiar with the domain) observers are able to judge creativity (Amabile et al., 2002). This would apply to any domain in which creativity is a valuable criterion. The assumption is that, based on general cultural values within a society, consistencies will underlie the assessments of judges (Child & Cordasco, 1970). In the assessment of both the aesthetic preference (Temme, 1983) and the level of creativity of artworks and designs, a higher level of agreement will be shown among people who have similar learning experiences in the area of art or design. Problems have arisen, however, regarding the idiosyncratic standards of professional judges. A number of studies report that in the judging of artworks the level of agreement among lay judges is often higher than among experts (Getzels & Csikszentmihalyi, 1976; Gordon, 1956; Hekkert & Van Wieringen, 1996; Runco & Charles, 1993). Runco et al. suggested that expert judges rely on high-level, esoteric, idiosyncratic standards (Runco & Charles, 1993). This makes for less awareness of differences among artworks than is found in groups of judges with lower expertise. Getzels and Csikszentmihalyi argued that experts have more difficulty assessing products in terms of their fundamental attributes than judges with an intermediate level of expertise (Getzels & Csikszentmihalyi, 1976). They assumed that experts are much too involved in objects as aesthetic wholes and therefore consider differentiation between attributes as spurious abstractions. Their findings were confirmed by Hekkert & Van Wieringen (1996). Correlations between mean ratings on originality and other criteria are much higher among experts than among nonexperts. The validity of subjective judgment is also open to question. An indication of validity might be that judges apparently have no difficulty in distinguishing between various assessment criteria; however, the results of correlational analysis in several studies do not confirm any clear distinction between them. The aesthetic value of the product seems to be strongly related to originality and creativity (Amabile, 1983; Getzels & Csikszentmihalyi, 1976). Findings regarding the relationship between creativity and technical quality are contradictory. In the study of Trowbridge and Charles, the hypothesis that creativity and technical competence can be separated into two distinct variables is confirmed with a correlation of nearly zero (Trowbridge & Charles, 1966). In contrast, in the studies of Getzels & Csikszentmihalyi (1976) and in most of Amabile's (1983) studies, the relationship between the two is quite strong. Although many studies show that creativity is interrelated with such concepts as aesthetic appeal, appropriateness, and (technical) quality, some authors still claim that creativity can be considered a separate construct (Amabile, 1983).

In this study we tried to find evidence to prove this assumption—that is, that creativity and other aesthetic criteria are different constructs—by introducing a discriminating variable called prototypical value. Based on information processing theory, Attractiveness of a stimulus increases the more it resembles the prototypical representation of that stimulus (Crozier & Chapman, 1984). If this theory holds well, then objects that, because they are original and unexpected, are by definition far from being prototypical representations, will be less attractive because of their divergence from the prototype. Because creativity is also characterized by concepts such as originality, the distance between a creative object and the prototypical representation, based on membership of the category of similar objects, is also by definition large, larger than the distance between the aesthetic appeal and the prototypical value.

To sum up all above we assigned 5 experts in field of architecture, 3 assistant professors, 1 associate professor and 1 full professor. They were all staff of Shahid Rajayee University. The group has been asked to score from scale of 1 to 10 to each of the projects and the mean of their score have been assigned to the student's design.

8. Analysis

All the students who finished the task with Sketch up confessed that the software is not appropriate to create complex geometries (double curves, non-standard architecture (NSA), non-Euclidean geometry, etc.) therefore they all had somehow similar results with two different mediums and that was different composition of Euclidean geometry. In the table of results it have been mentioned that this is the limitation of the software that they cannot create complex geometry (**Table 1**). By decision of the jury, among six students who have been used Sketch up, the results of three students out of six were more creative. The other four received "The same results as pen and Paper" therefore they received "No change" on comparing the results in the table (**Table 1**).

Among five students who have been chosen 3D max, four of them were more creative and one of them received "No change" in results. The remaining six chose Revit for their design and among them two students received "No change" and the other four were more creative (**Table 1**).

In general, 11 students out of 18 were more creative (61.1%). 42.9 % of the students who chose Sketch up received the lowest score in being creative and people who chose 3D max had the best results: 83.4% , and finally 66.7% of students who worked with Revit were more creative (**Table 2**).

Table 1. Summary of experiment and interviews.

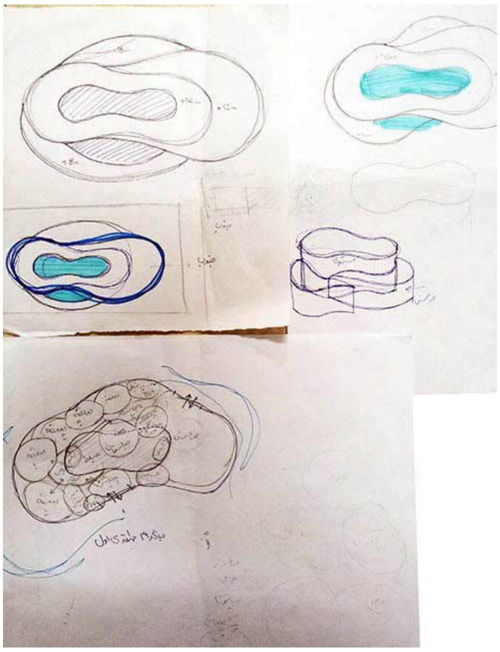
No	Name	Software	Subjective opinion in competency in software	Ability to create complex geometry using 3D software	Why didn't you choose more complex geometry?	Judge's decision on the results of switching between 2D and 3D
1	Z. Badamchi	R	70%	Yes	Subjective	Yes
2	M. Rahou	R	50%	No	Not expert	Yes
3	A. Souki	3D	30%	No	Not expert	No change
4	Y. Asemi	3D	50%	No	Subjective	Yes
5	P. Zarghami	S	90%	No (SL)	SL	Yes
6	F. Jafari	3D	80%	Yes	Subjective	Yes
7	P. Zamannejad	S	90%	No (SL)	SL	Yes
8	M. Mohamadi	R	70%	No	Not expert	Yes
9	D. Faturechi	S	70%	No (SL)	SL	No change
10	Sh. Ebrahimi	S	50%	No (SL)	SL	No change
11	Z. Dehghani	S	50%	No (SL)	SL	Yes
12	F. Jabari	3D	40%	No	Not expert	Yes
13	E. Taghavi	S	70%	No (SL)	SL	Yes
14	E. Akbari	R	80%	Yes	Subjective	Yes
15	A. Aynevand	R	70%	Yes	Subjective	No change
16	J. Mousavi	S	80%	No (SL)	SL	Yes
17	M. Makki	3D	90%	Yes	Subjective	Yes
18	M. Ozgoli	R	80%	Yes	Subjective	No change

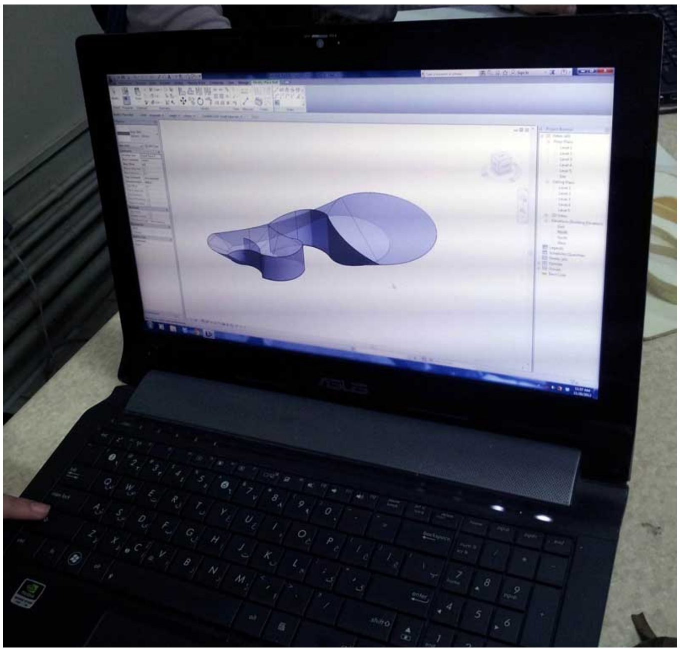
SL: Software limitation, R: Revit, S: Sketch up, 3D: 3D Max.

Table 2. Percentage of change.

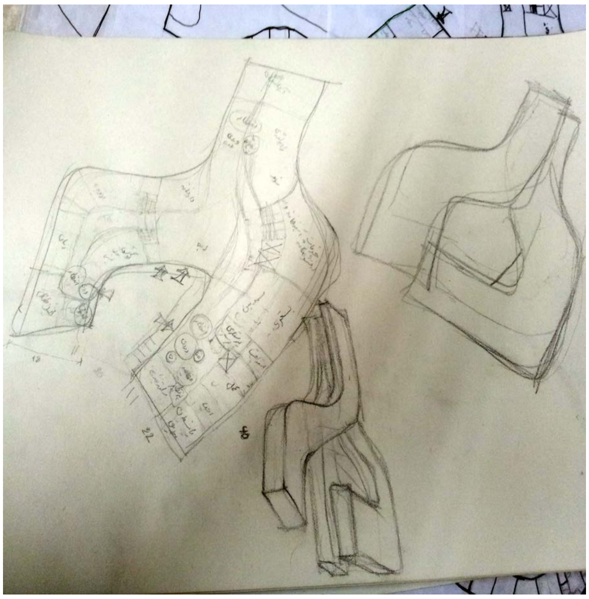
Software	Percent of students who are more creative after changing the medium
3D max	83.4%
Sketch up	42.9%
Revit	66.7%

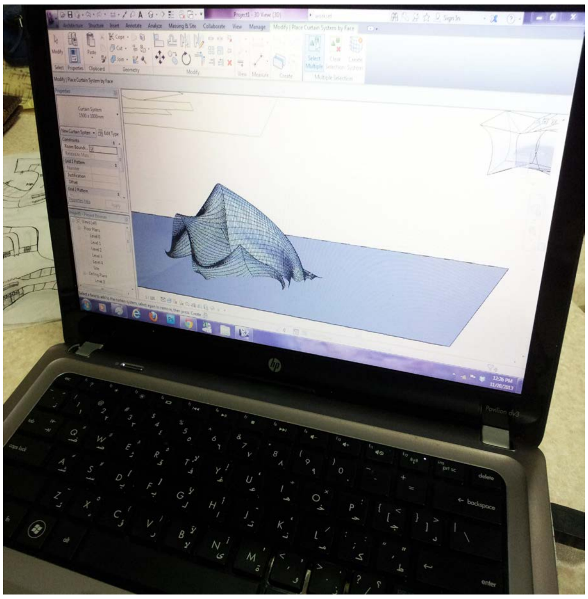
Sample works of some of the students are as follows:



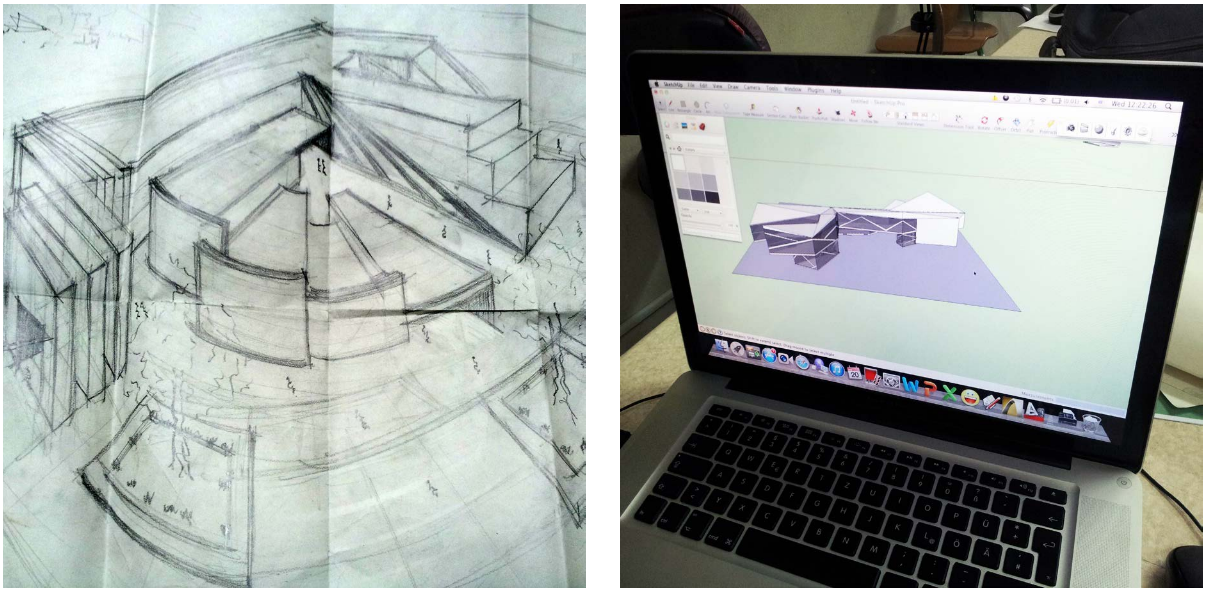


Sample 1.





Sample 2.



Sample 3.

9. Other Advantages of 3D Workspaces

Beside the aforementioned advantage of switching to 3D environment, ceasing use of 2D pen and paper and turn to 2D and 3D computer interface will have plenty of other advantages:

- **Better visualization:** We live in a 3D world and the brain gets used to visualize objects in 3D. When it comes to communicating with a design, we naturally prefer a 3D images, models, or animation for better perception over a 2D technical drawing. In the 2D world, the brain should capture different 2d angels and fuse them mentally and create a 3d visualization in order to perceive the image. It takes a lot of effort and especially the task becomes almost impossible when it comes to non-Euclidian geometries and NSA (non-standard architecture).
- **Eliminate manual updates:** In 2D, upon each change in design the current drawing view will be disconnected from the other two. You have to manually update every drawing view whenever a change occurs. Change one part and you not only have to include that change in each of the three drawing views for the part, you must also change every view of every assembly in which that part is used. Therefore, updating the design for each drawing view is one of the benefits of working in 3D workspaces.
- **Reuse existing designs and modifiability:** The unique aspects of 3d environment will allow you to make easy and extensive reuse of existing designs (by saving the file!) As discussed earlier, "associatively" means when you change a design model, the change automatically goes through all the other places where that model is used. Modifiability let you reuse existing designs to create new versions or configurations easily.
- **Advance development cycles with quick simulations and virtual testing:** Other benefits of working in 3d workspace are the agile ability for simulations, virtual testing, analysis, and optimization. For instance Autodesk® Vasari with integrated analysis for energy and carbon, providing design insights in early stages of decision making. Vasari is focused on conceptual building design using both geometric and parametric modelling. It supports performance-based design via integrated energy modelling and analysis features.
- **F2F (File to Factory) for rapid prototyping:** New fabrication techniques enormously rely on 3D CAD model. CAM (computer aided modelling) will help us create a faster production process and components and tooling with more precise dimensions and material consistency.

It is always suggested that an architect student should be master of all the tools he/she has, whether a 2D tool or 3D interface. This shouldn't be implied for the above experiment that the architects should ignore pen and paper, always a combination of all the tools together can have the best answer. However, because of the powerful effects of CAAD tools for idea generation, it is wise to implement specific workshop in architecture pedagogy to enhance their implication of CAAD in the design process. The more students get familiar with 3D CAAD interfaces, the more creative ideas they can reach to.

10. Conclusion

Following the ideas of Edwin Abbott Abbott, the writer of "Flatland" and also Kas Oosterhuis in his book "Towards a new kind of building", authors considered a hypothesis: if we increase the dimension of the starting point of design from flatland (pen and paper) to Spaceland (3D environment), we will have more creative results. Based on this premise, an experiment has been designed and a group of 18 students have been asked to design an architectural task once with pen and paper and the next time with a 3D environment of their own choice. The jury (group of 5 experts in field of architecture) compared the results and decided that among them 61.1% of students have more creative results when they changed their dimension of starting point. Students who chose Sketch up as their 3D environment got the least score because of software limitation on creating complex geometries and students who chose 3D max had the best results. Level of proficiency of students in software is important for choosing complex geometries and students with less skill tend to stick to conventional Euclidean geometry.

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