

# Measuring the Creativity in the Formation of Initial Ideas Using Hand Drawing in the Architectural Design Process\*

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## ABSTRACT

Gaining knowledge of the design process and the events that occur during the design process of professional architects can greatly help increase design knowledge. One of the problems observed in the Iranian academic and professional fields nowadays, is the lack of sufficient knowledge of such topics and the use of the results of such research. The study of creativity in the design process of architects, known as Situated Creativity (S-creativity) occupies a significant part of studies in the field of the design process. All the design processes gone through the idea generation stage by professional architects do not have the same level of creativity, and studying the processes including the optimal level of creativity will definitely be more valuable. The current study aims to measure the level of creativity in the ideation stage among Iranian professional architects. In this regard, the ideation stage in the design process gone through by eight Iranian professional architects is investigated. These architects used sketches, including freehand sketches and diagrams, in their ideation process. The protocol analysis using retroactive verbalization, and linkographic analysis are the research methods used in this study. Divergent-convergent thinking and creative insights were measured in architects' design process through quantitative analysis of Linkograph and analysis of Linkograph structure.. The findings indicate a good level of creativity in the design process of some architects, indicating that the control of convergent and divergent thinking, which is formed unconsciously in the mind of a professional architect, can play a very decisive role in the desirability of creativity and of course, the desirability of the ideation stage in the design process.

**Keywords:** Creativity, Protocol Analysis, Linkography, Creative Insight, Divergent-convergent Thinking.

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## 1. INTRODUCTION

In the study of creative design, one of the important aspects is to distinguish between different types of creativity. Boden (2004) defines two types of creativity. The first type is Historical Creativity (H-creativity), which refers to a design formed by the designer for the first time in history; And the second type is Psychological Creativity (P-creativity) in which the designer creates a design for the first time in his professional life that is different from what he has designed before. Suwa, Gero, and Purcell (2000) have defined a third type of creativity called Situated Creativity (S-creativity). This type of creativity appears during the design process and it is when the design includes ideas that were not expected to be in the design initially in the design process. Therefore, the design includes ideas that are not necessarily new

to the designer in a certain way but considered new in the specific situation of the design process. This research seeks to study the third type of creativity, S-creativity, which is formed during the design process.

the creativity formed during the ideation stage in the design process, or S-creativity is one of the issues that has not been addressed in the field of creativity studies, especially in Iran. Definitely, not all design processes of architects have a good level of creativity in the ideation stage. The findings of the studies on methods used to measure the desirability of creativity in the design process of architects can be also used for architectural design education. Architectural design professors can use the findings of the current research to advance and apply new educational methods in the field of architectural design education.

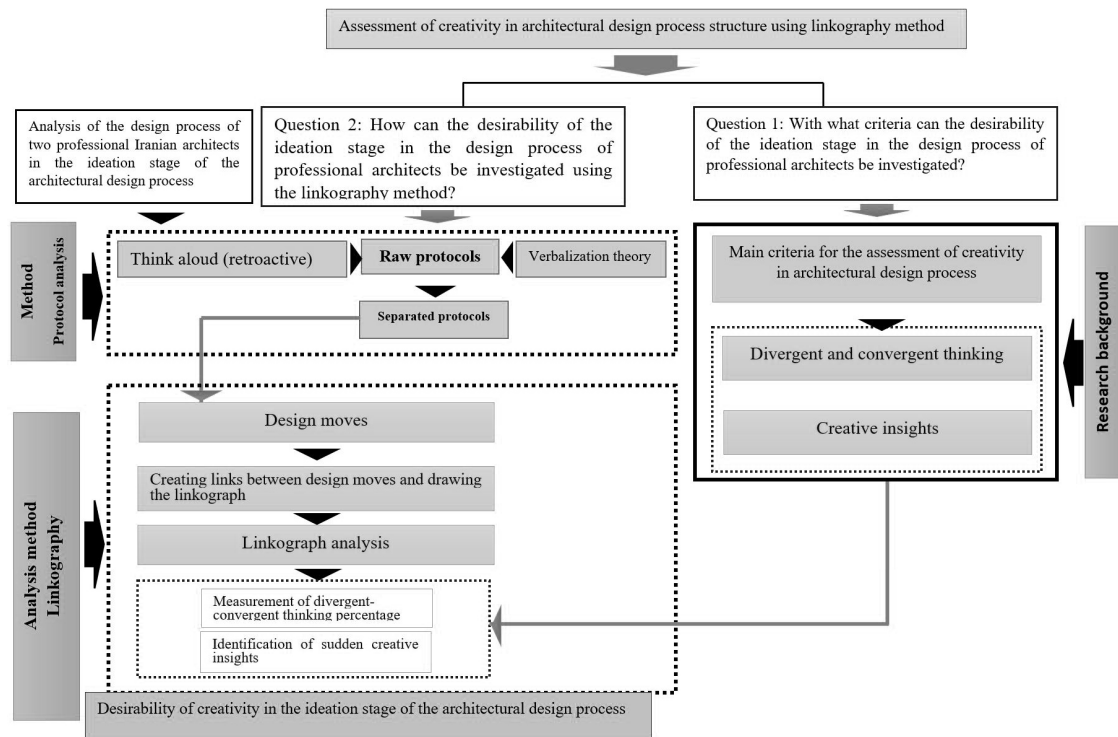


Fig. 1. Research Process

The present study, after examining protocol analysis as an empirical research method for research in the field of the design process, describes the linkography analysis as a method for analyzing the design process structure formed based on the data obtained from the protocol analysis. Then, the discussion of creativity in the design process, as well as the topics raised in this field, such as creative insights and analysis of the role of divergent and convergent thinking in the formation of a creative process, are examined. Finally, the creativity in design process of eight Iranian professional architects has been measured by this method. The research process is presented in

Figure 1.

## 2. RESEARCH BACKGROUND

The research background can be examined in two parts: the first part reviews studies on creativity in the design process from a cognitive point of view, and the second part discusses the linkography method and how to measure creativity using this method.

Several studies have been conducted in the field of creativity in the design process from a cognitive point of view, among which we can refer to the research by Dorst and Cross (2001), Suwa, Gero, and Purcell

(1999; 2000) and Akin & Akin (1996).

Suwa, Gero, and Purcell (2000) analyzed the cognitive activities of a professional architect during the design process and concluded that design is a situated activity. That is unexpected discoveries occur during the design process. These researchers proposed the third type of creativity called S-creativity. Akin and Akin (1996) believe that discovering a creative solution depends on having a sudden insight into the mind.

Some researchers in the field of linkography and the application of this method in analyzing the structure of the architectural design process have conducted studies on how to measure creativity using this method, among which two studies can be mentioned. The first research was conducted by Gabriela Goldschmidt (2016), who is also the founder of the linkography method. In her research, convergent and divergent thinking has been quantitatively measured through the Linkograph.

Another research mainly focused on creative insights in the process of architectural design, was conducted by El-Khouly and Penn (2013). According to these researchers, sudden creative insights in the design process can be achieved through the analysis of the linkograph structure. Another research in the field of linkography in the country examines the impact of available technology on the thinking process of industrial designers (Jahanbakhsh and Pourmohammadi 2017).

### 3. METHODOLOGY

The present study was carried out using protocol analysis. This method was first proposed in the field of cognitive psychology, and later, it was considered a very suitable method for studying the design process by researchers in the field of research design. The data were analyzed through linkography. This method analyzes the structure of the design process using the data obtained from the protocol analysis. These two methods are explained in detail below.

#### 3.1. Protocol Analysis

The protocol analysis consists of providing short-term design exercises to the subjects and examining their behavior. A protocol is a time portion of the recorded behavior. The protocol analysis method is based on psychological theory for information processing. The inherent characteristic of information processing theory is based on the idea that thinking is both a process and a product of information processed by the brain (Eckersley 1988). Since thinking is an activity that cannot be directly observed, even limited and mediated access to what goes on in the human mind can provide knowledge about this field. In this regard, under controlled conditions, people (after they have been trained to express their thinking while they are thinking) can remarkably reveal an accurate picture of

the cognitive process they go through while solving a problem. Since people report what is going on in their mind at the same time they are thinking, it can also be referred to as "think aloud", although later, this process was reviewed and the methods by which people reported their thoughts after the experiment or during the experiment were also considered. For example, in the protocol analysis of a retroactive design process, the person who is tested, after performing the test, reports his thought. In the research on simultaneous and retrospective verbalization, evidence suggests that think aloud during the experiment while working on the exercise can interfere with the designer's performance and distort it. One of the advantages of retroactive verbalization is that it does not interfere with the process of exercise solving. Among the disadvantages of the retroactive method is the possibility of forgetting some activities and choosing favorite items by the designer. The entire design process can be filmed to facilitate the research process, and then it can be shown to the person. It makes the designer better remember things such as the drawings he drew during the design process. Then the designer's speech is recorded and after that, the researcher transforms this protocol into 4 separate parts. These parts are later presented and analyzed in the linkography method in the form of design moves. Protocol analysis relies heavily on information produced in the form of external representations, such as oral statements, drawings, and writings.

#### 3.2. Linkography Analysis

Linkography is one of the methods to analyze the structure of the design process, done through protocol analysis. A linkograph is actually a modified representation of a matrix. In general, in this method proposed by Goldschmidt, a design practice protocol is divided into "design moves". In fact, each segment in protocol analysis is considered a design move in Linkograph. Then, for each of the moves, the presence or absence of links with other moves is considered. These links are finally shown in the form of a linkograph. The components and patterns that may be formed in the linkograph's structure are as follows:

a) Design move: The definition provided by Goldschmidt for a "design move" is "a step, a movement, a function that moves the design situation from the state it previously was to a new one" (Goldschmidt 1995).

b) Link: If there is a connection between a design move and the next or previous design move, a link is established between these moves. The only criterion for identifying the link between design moves is the researcher's judgment based on his understanding of the design process and the resulting protocols.

c) Chunk: A group of moves that have remarkably found a link between themselves.

d) Web: A large group of links among a relatively

small number of moves.

f) Saw tooth track: special sequence of links.

e) Forelink: A state in which the design move has a link with a move after it is called a forward link.

j) Backlink: A state in which the design move has a link with a move before it is called a backlink (Goldschmidt 1992; 2014).

Figure 2 shows a linkograph and the patterns that may be formed in its structure.

Critical moves in the linkograph, which are shown by the CM symbol, are moves that have generated

more links. These moves are of great importance in advancing the design process. Some thresholds (usually three thresholds) are specified to determine critical moves,. For example, a threshold of 5 indicates design moves that have 5 or more links with moves ahead or behind them. In critical moves, the moves that are connected with moves ahead of them are called forelink critical moves (CM>), and moves that are connected with moves before them are called backlink critical moves (CM<).

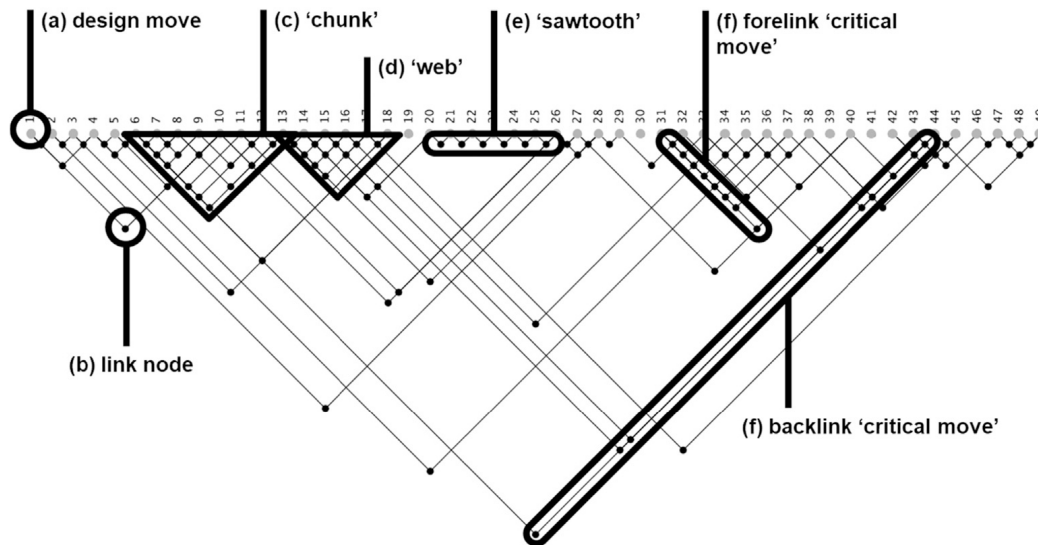


Fig. 2. The Patterns Formed in the Linkograph Structure

## 4. THEORETICAL FOUNDATIONS

Studies related to the subject of creativity in the architectural design process and different approaches in this field, as well as topics such as divergent-convergent thinking or creative insights which are indicators of creativity, form the theoretical foundations of the current study.

### 4.1. Creativity in Design Process

The classification of different approaches to the design process is a basis for analyzing and describing creativity in the design process. This classification, which is formed based on research design patterns, can be studied in two main approaches:

1. Design as a problem-solving process
2. Design as an intellectual act (Dorst and Dijkhuis 1995; Dorst 2006).

The first approach, which mainly dates back to the 60s, is based on the application of systematic, logical, and scientific methods. In this approach, design is a procedural and incremental process. In other words, during the design process, an analytical hierarchy of the important aspects of the design problem, then the combination of solutions, and finally the evaluation

of these solutions are formed, which are placed in a linear manner, one after the other. Based on Simon's thoughts (Simon 1969), this view considers the design process as a process of "problem-solving" or "information processing". Models of creative processes that consider the creative process linearly can adapt to this approach. One of the most well-known models of creativity is that of Wallas (1926). He considers four stages of the creative process, which include: preparation<sup>1</sup>, incubation<sup>2</sup>, illumination<sup>3</sup>, and validation<sup>4</sup>. This process is linear and there is no return to the previous steps.

In the second approach, which started around the early 70s, design is no longer considered a sequence of activities, and the process and content of the design activity are inextricably linked. In the second approach, the designer no longer goes through the process of analysis, composition, and evaluation in the course of the design process in sequential order, but in the form of a cycle, and sometimes deals with these things simultaneously. This approach, which is based on Schon's views (1983) considers design as a thoughtful conversation with the situation. In this case, the design problem recognition activities are highly dependent on the creative results.



## 4.2. Divergent and Convergent Thinking

Divergent thinking is the thinking developed in divergent directions, which means that it considers different aspects of the design problem and sometimes ends up with new ideas and solutions. Convergent thinking refers to thinking focused on gathering information to solve the design problem. Divergent and convergent thinking is observed many times in the form of a cyclical model during the design process. Neuroscientific evidence is based on the fact that frequent transitions between focused and unfocused attention to stimuli in a memory activity, which are equivalent to convergent and divergent thinking, are a sign of creative thinking (Goldschmidt 2016). The interest in studying the divergent and convergent thinking is rooted in the study of creativity. Many psychometric studies in the past have relied on divergent thinking to test creativity. Also, in the past, and even today, in some research, divergent thinking has a more prominent role in measuring creativity in the design process. For example, Taura and Nagai (2013) emphasize in their study that creative design depends on the designer's ability to develop his thinking space (divergent thinking). Even though these researchers emphasize the importance and role of back and forth moves in the design process, their main focus is on divergent thinking and they consider a minor role for convergent thinking. Meanwhile, many researchers insist that a creative design process is not only based on divergent thinking, but convergent thinking also plays an important role in it. According to Tversky and Chou (2010), successful designers need both convergent and divergent thinking. One of the manifestations of convergent and divergent thinking in the design process is the designer's sketches. When the designer shifts his attention from one sketch to another, this is a sign of divergent thinking. While focusing on a sketch and developing it forms convergent thinking. Experienced designers are implicitly aware of this issue and use both types of thinking repeatedly.

## 4.3. Creative Insights

Creativity in the design process is usually characterized by the emergence of creative insights. Two types of creative insights can be identified during the design process (El-Khouly and Penn 2013). In the first type, creative insights are formed incrementally, and are gradually transition from one idea to another during the design process. This perspective, which is based on a trial and error approach to developing a creative solution, is close to the logical paradigm of the 60s. In the second type, creative ideas appear as sudden mental changes during the design process. Cross (1997), who uses the term "creative leap" in explaining creative insights, considers sudden insights developed during the design process as building a "creative bridge", a bridge between the problem space and the solution

space. It is made by identifying a key idea. From this point of view, creative design is an exploratory process and does not have an exploration aspect. The emergence of sudden mental insights that lead to the creation of new solutions is a situated event.

## 5. STUDIES AND INVESTIGATIONS

The samples considered for the research are eight Iranian professional architects with a work experience of 15-30 years. The theme of the design was an art museum on a specific plot. The site had an abnormal shape (Fig. 3) and could be accessed from both the west and north sides. The samples were free to choose where the site was or what its scale was. The architects were asked to consider functions related to the museum, such as galleries, ticket sales, etc., as well as a library in the design of the museum. The time allocated for the design was 30 minutes.

The protocol analysis was carried out retroactively. The entire design process was filmed. Architects did not speak during the design process. After the time was up, the film was played for the architect and he was asked to report his thinking from each stage at the same time the film was shown. The architect's speech was recorded and then the researcher turned it into separate chunks. Each of the chunks is a design move in the Linkograph, which was drawn and analyzed by identifying the links between the design moves.

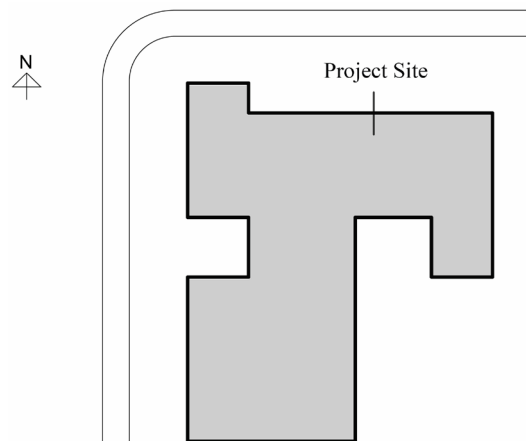


Fig. 3. The Site Intended for the Art Museum Design

## 5.1. Assessment of Divergent and Convergent Thinking

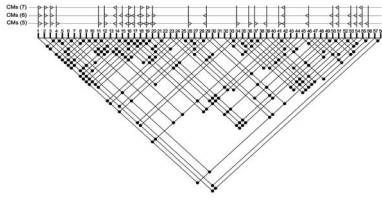
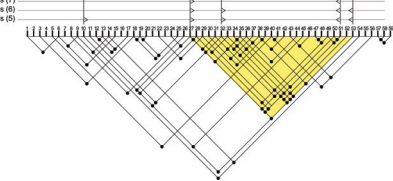
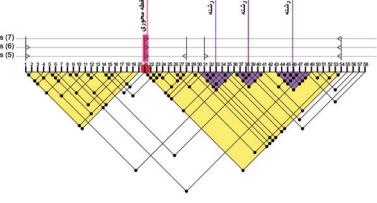
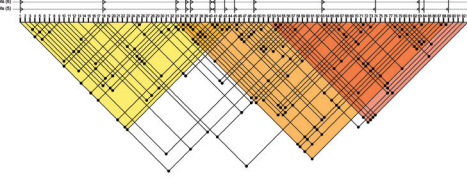
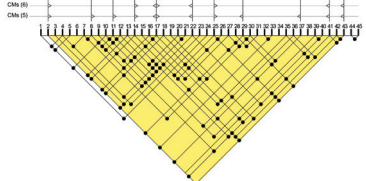
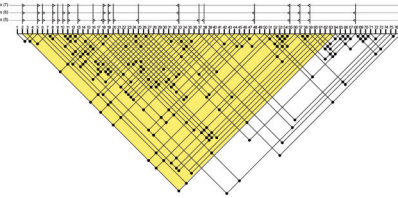
Forelinks in Linkograph indicate divergent thinking, while backlinks indicate convergent thinking. Goldschmidt (2016) has taken the critical moves (CM) as the basis to measure the percentage of divergent and convergent thinking during the design process. This means that the percentage of forelink critical moves (CM>) compared to the total critical moves at the defined threshold, shows the percentage

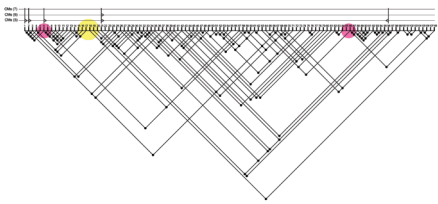
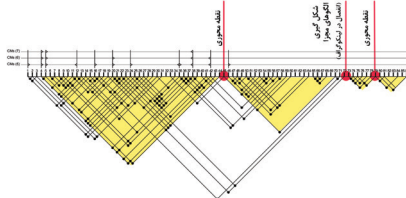
of divergent thinking at the corresponding threshold. Regarding the amount of convergent thinking, the percentage of backlink critical moves (<CM) compared to the total critical moves at the respective threshold shows the percentage of convergent thinking at the desired threshold. Goldschmidt, based on numerous research conducted on different designers and the result of their linkograph, knows the ratio of forelink critical moves to backlink critical moves for the formation of a creative process to be close to 60 to 40% (Goldschmidt 2016). In this case,

the design process is a favorable process in terms of the desirable formation of convergent and divergent thinking, as well as a desirable process in terms of creativity.

In the study conducted on eight Iranian professional architects, after drawing the linkograph, the analysis of the percentage of divergent and convergent thinking in the critical moves in the linkograph was done at three thresholds of 5, 6, and 7. The results of this analysis are presented in Table 1.

**Table 1. Assessment of Divergent and Convergent Thinking by the Use of Linkography Analysis in the Ideation Stage of the Design Process for Eight Professional Iranian Architects**

Studied Architects	Linkograph	Divergent-Convergent Thinking		
		Threshold	%CM>	%CM<
Architect No.1		CM5	51.9	48.1
		CM6	47.8	52.2
		CM7	68.8	31.2
Architect No.2		CM5	58.06	41.94
		CM6	50	50
		CM7	50	50
Architect No.3		CM5	57.58	42.42
		CM6	60.87	39.13
		CM7	47.06	52.94
Architect No.4		CM5	70.19	29.81
		CM6	79.75	20.25
		CM7	86.30	13.70
Architect No.5		CM5	50.62	49.38
		CM6	50.82	49.18
		CM7	51.35	48.65
Architect No.6		CM5	58.62	41.38
		CM6	61.90	38.10
		CM7	65.43	34.57

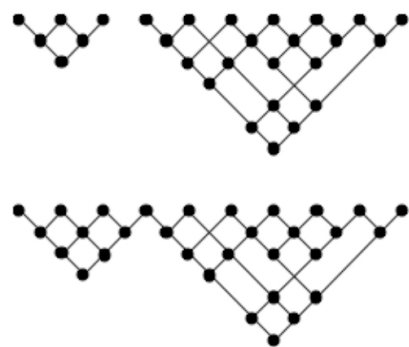
Studied Architects	Linkograph	Divergent-Convergent Thinking		
		Threshold	%CM>	%CM<
Architect No.7		CM5	75	25
		CM6	100	0
		CM7	0	0
Architect No.8		CM5	61.25	38.75
		CM6	60	40
		CM7	64.29	35.71

By examining the results, it can be seen that the divergent/convergent thinking ratio of 60:40 has been maintained in the design process of architects Nos. 3, 6, and 8. Therefore, it can be said that this process has undergone a favorable process in terms of creativity. While in the design process of architects Nos. 4 and 7, compared to the optimal divergent/convergent thinking ratio of 60:40, the ratio of divergent thinking is much higher than convergent thinking. This shows that the architect, in the entire ideation stage of the design process, has made a lot of effort for creating different ideas and is less focused on developing and focusing on a specific idea. On the other hand, in the design process of architects Nos. 1, 2, and 5, the percentage of convergent thinking is greater than divergent thinking or in some cases, they are equal. Comparing these figures with the favorable divergent/convergent thinking ratio of 60:40, it can be concluded that the architect in the ideation stage, where divergent thinking needs to play a stronger role, converges his thinking more than necessary and he has not taken into account ideas that are somewhat different from each other, and has not diverged his thinking. Therefore, according to the definition provided by Goldschmidt (2016), these processes cannot be considered a creative process in the field of architecture because the relative balance between divergent and convergent thinking has not been established during the design process.

## 5.2. Assessment of Creative Insights

Insight types either rely on memory and retrieving good ideas from memory that result in the formation of incremental insights during the design process, or they are unconscious actions that operate beyond the designer's awareness that lead to sudden insights (El-Khouly and Penn 2013). Sudden insights make a significant change in the linkograph structure. The occurrence of fundamental changes in the design process, in most cases, causes the formation of separate chunks or sub-webs in

Linkograph. Transitioning from one idea to another and the occurrence of creative leaps are such types. If the changes happen quickly, the structure of the design process, the design problem, and the idea will change fundamentally. The whole situation may be restructured again. This state in the linkograph process may be a complete disconnection of two patterns or a pivot point. Therefore, these pivot points formed in Linkograph can signify a creative leap in the design process. This can be identified and confirmed by analyzing the linkograph structure with consideration for the protocol analysis and testing process. Figure 4 shows an example of the formation of separate patterns and the the pivot point in the linkograph.



**Fig. 4. Formation of Separated Patterns and the Pivot Point in the Linkograph**  
(El-Khouly and Penn 2013)

In the study conducted on eight professional architects, the pivotal points can be seen in the linkograph structures of architects Nos. 3, 7, and 8, which show sudden creative insight. This means that the design process is non-gradual and the architect redefines or reframes the architectural problem during the process and redefines the situation. In this sense, the architect's design process has a research and discovery aspect and tries to create ideas in this way. These architects' approach to the design process

is close to the model of "design as an intellectual practice" proposed by Schon (1983). For example, in the kinkograph of architect No. 7 (Fig. 5), sudden creative insights (pivot points) can be identified in his two design moves. Move No. 6 at minute 2:52 and move No. 86 at minute 26:18 show sudden creative insights. In move No. 6, which occurred in the initial stages of the design process, the designer, after facing the site and its limitations, tries to understand the potential of the site and its zoning. In this move, it seems to the designer that it is better to consider two approaches, one facing the outside

and the other related to the inside of the project. The diagram drawn by the architect at this stage can be seen in Figure 6. The architect's words related to this move are as follows:

"I went back to the site again. What features does the site have? Should I consider the side faced with the city on the north and west as very serious walls with the dignity that is working with the city and as soon as we go inside it, it suddenly starts to break down, working outside with the city on the outside, and I had a lot of freedom on the inside".

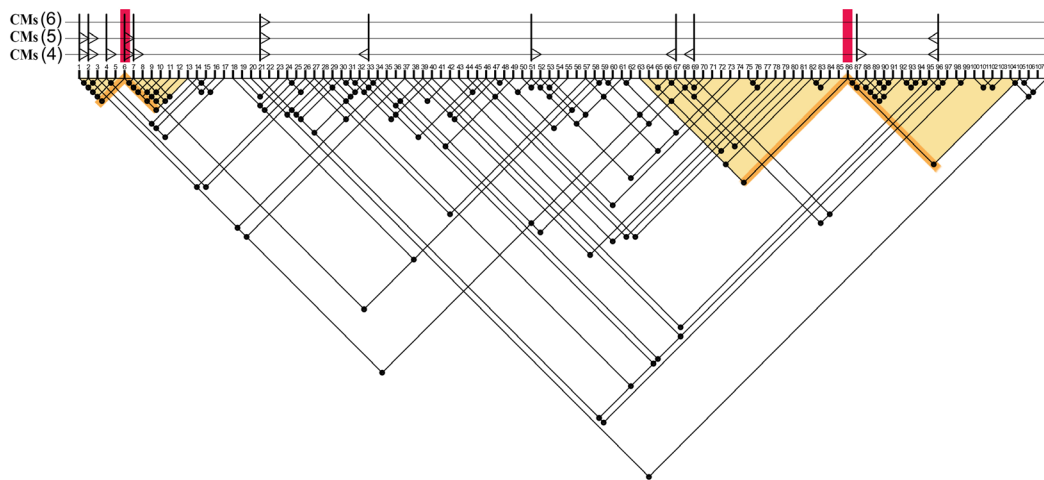


Fig. 5. Design Process Linkograph of the Architect 7



Fig. 6. The Diagram Drawn by Architect No. 7 in Move 6

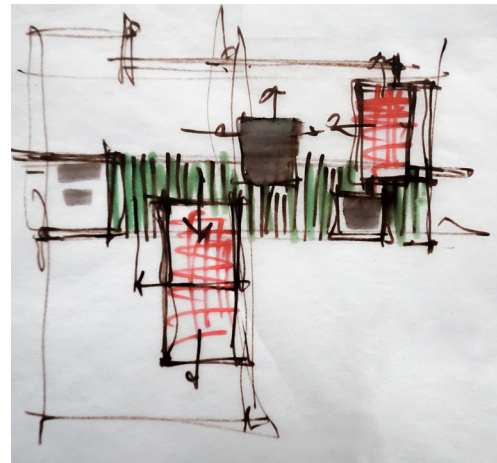


Fig. 7. The Diagram Drawn by Architect No. 7 in the Move No. 86

In the second sudden creative insight, the architect creates courtyards within the scope of the project, after successive efforts and trying different options for site zoning during the design process, but since the formation of scattered courtyards does not convince the designer, suddenly, in this move, it seems to him that it is better to organize the yards around one axis. This sudden creative insight occurs in move No. 86. The diagram of this move can be seen in Figure 7. The

architect's words related to this move are:

"Here I went to another task, can I bring all these yards on the same axis that I drew before, which had two yards?"

In the linkograph of architect No. 3, a pivot point can be identified in move No. 21 (Fig. 8). In this move, which was formed at minute 6:06 of the design process, the architect, after drawing several volumes of the museum, suddenly thought that it would be



better to create volumes that, while communicating with each other, are diverse. He has expressed the following:

"One of the topics that came to my mind was that there should be a variety between sizes. There should be a relationship between all these volumes, but they should not be the same shape. I thought of covering one of the volumes with a curved space, the other

with a false or a second view".

In fact, from this stage onwards, "diversity" has become a pivotal issue in the architect's design process, which he refers to many times in the next stages and subsequent drawings. The volume diagram drawn by the architect, in move No.21, can be seen in Figure 9.

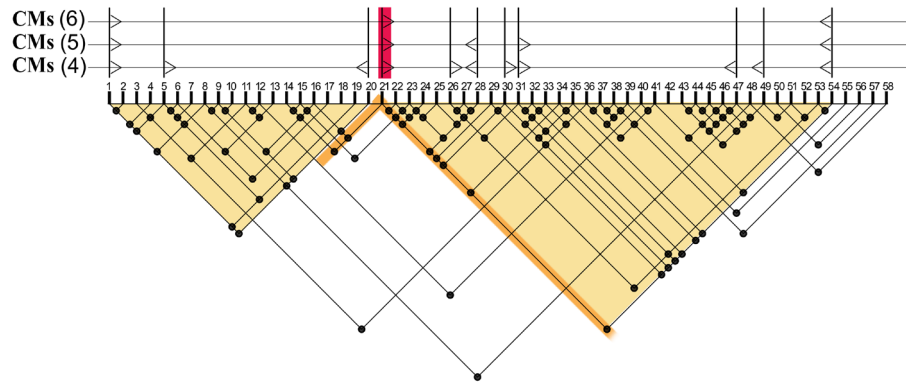


Fig. 8. Design Process Linkograph of Architect No.3

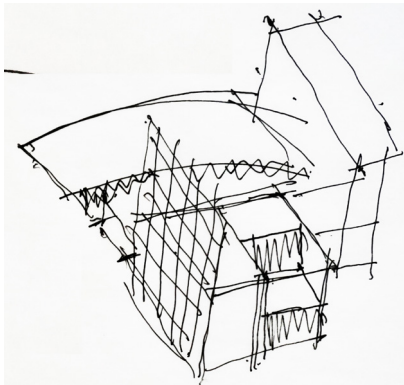
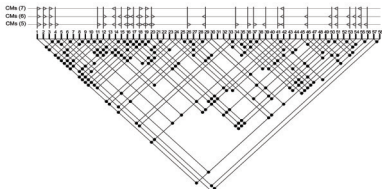
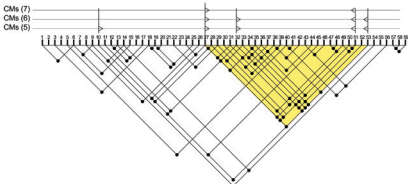


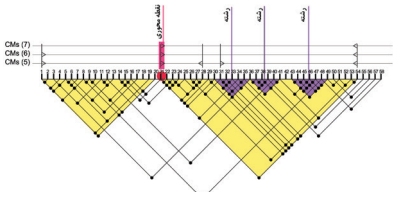
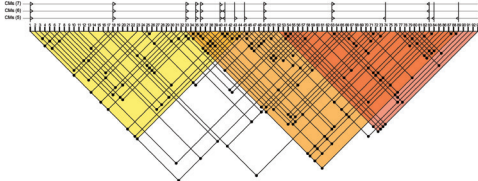
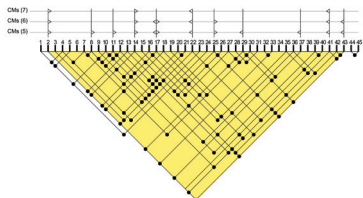
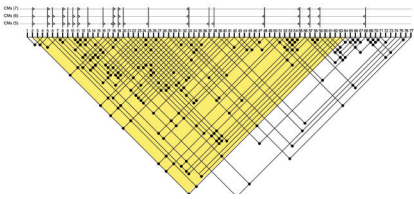
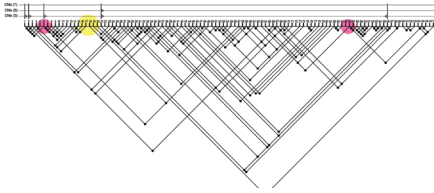
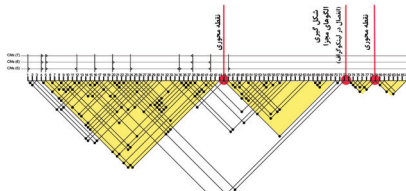
Fig. 9. Volume Diagram Drawn by Architect No.3 in Move No.21

On the other hand, the design process approach of architects Nos. 1, 2, 4, 5, and 6 was close to the model of the "logical problem-solving process" proposed by Simon (1969). In the design process of these architects, the sudden creative insight that leads to the formation of a pivot point in the linkograph structure cannot be seen. This shows that the architect defines the design problem at the beginning and searches for its solution until the end of the design process. This process is not exploratory.

Table 2 shows the analysis done in relation to the creative insights formed in the ideation stage of the architects under research.

Table 2. Analysis of Creative Insights Formed in the Ideation Stage of the Design Process of Eight Iranian Professional Architects

Studied Architects	Linkograph	Creative Insights
Architect No.1		A pivot point that shows sudden creative insights is not seen in the linkograph structure. Lateral transitions and incremental creative insights can be seen between moves Nos. 3 to 20.
Architect No.2		In the linkograph structure, there is no pivot point that shows a sudden creative insight. Studying the lateral transitions, only one case of incremental creative insight into the design process can be seen in move No.49.

Studied Architects	Linkograph	Creative Insights
Architect No.3		In the linkograph structure, a pivot point can be seen in design move No.21, which shows a sudden creative insight. Incremental creative insights are also well formed in the form of lateral transitions in the design process.
Architect No.4		In the linkograph structure, there is no pivot point that shows a sudden creative insight. Lateral transitions, which indicate incremental creative insights, are observed from move No.65 onwards, i.e. the final one-third of the linkograph.
Architect No.5		In the linkograph structure, there is no pivot point that shows a sudden creative insight. Lateral transitions, which indicate incremental creative insights, are visible in limited numbers and the first half of the Linkograph.
Architect No.6		In the linkograph structure, there is no pivot point that shows a sudden creative insight. Lateral transitions that indicate incremental creative insights flow throughout the design process and are not concentrated in a specific area.
Architect No.7		Sudden creative insights (pivot points) can be identified in two design moves. Additional creative insights are also well observed in the architect's design process.
Architect No.8		Sudden creative insights (pivot points) can be identified in two design moves. Additional creative insights are also visible in the architect's design process.

## 6. FINDINGS

The level of creativity using Linkograph in the design process of eight professional architects who participated in this research was measured with consideration of the two criteria of divergent and convergent thinking, as well as sudden creative insight. The research data findings indicate that sudden creative insights are observed in some architects' design process. Sudden creative insights can be recognized in the linkograph structure through

the formation of a pivot point, which indicates a creative leap. The formation of these pivot points in the linkograph structure indicates a non-incremental or gradual design process and shows a research approach to the design process (El-Khouly and Penn 2013). This means that the architect redefines or reframes the architectural problem and redefines the situation and tries to create an idea through an exploratory process. This approach is very close to the model of "design as an intellectual practice" proposed by Schon (1983).

On the other hand, by quantitatively measuring the percentage of divergent and convergent thinking in the design process of architects, the divergent/convergent thinking ratio of 60:40 was observed in the design process of architects Nos. 3, 6, and 8, which is considered to be a favorable level for a creative design process, while in the design process of other architects, this relative balance between divergent and convergent thinking did not exist. In some cases, the percentage of divergent thinking is much higher than convergent thinking, which indicates that during the design process, the architect focused more on the trial and error of different ideas and did not focus on choosing and developing a specific idea. Also, in the ideation stage of the design process of a group of architects, a higher percentage of convergent thinking than divergent thinking, or in some cases, an equal ratio is seen. This indicates that the architect focused on one idea during the ideation stage and did not consider different ideas, especially at the beginning of the ideation stage of the design process.

## 7. CONCLUSION

The creative process in the ideation stage of architectural design can be identified through its characteristics, the most important of which is the back and forth process between divergent and convergent thinking and establishing a relative balance between these two types of thinking with the relative predominance of divergent thinking over convergent thinking (approximately with a 60: 40% ratio). On the other hand, during the ideation stage of the design process, we witness the formation of creative insights formed in two types of incremental creative insights and sudden creative insights. Measuring divergent-convergent thinking, as well as creative insights, are the criteria through which the desirability of a creative process can be measured in the ideation stage. What can be achieved through linkography analysis in this field is the quantitative measurement of divergent-convergent thinking through linkograph, as well as the identification of sudden creative insights through changes in the linkograph structure.

During the analysis of the linkographs of eight Iranian professional architects, it was observed that in the linkographs of three architects, sudden creative insights appeared, which shows the approach of "design as an intellectual practice" in the ideation stage of the design process. The ideation process of five other architects lacks sudden creative insights and only incremental creative insights are visible, which shows the approach of "design as a problem-solving process". Both types of these insights can be seen in the ideation process of the design process of the eight architects studied in this research, and in this sense, the ideation process of all architects is creative. But what distinguishes their design ideation process from each other is the designer's ability to create a balance between divergent and convergent thinking during the design process. Architects Nos. 3, 6, and 8 have had a good ability to balance divergent and convergent thinking. These architects, after considering several ideas at the beginning of the design process, finally focused on one idea. This is not the case with other architects, for example, architects Nos. 4 and 7 tried many different ideas during their design process and this prevented them from focusing and developing an idea or forming a desirable convergent thinking. On the other hand, architects Nos. 1, 2, and 5 have focused more on single idea from the beginning of the ideation process, and as a result, the thinking process has become more convergent, which causes the lack of relative balance between convergent thinking and has diverged. Therefore, the ideation stage of the design process of architects Nos. 1, 2, 4, 5, and 7 cannot be considered a creative process. Therefore, according to the optimal formation of the ratio of divergent to convergent thinking in the ideation stage of the design process of architects Nos. 3, 6, and 8, according to the criteria considered in this research and the comparison between these three architects with other architects participating in the research, the ideation stage of the design process of these three architects is favorable in terms of creativity and has higher creativity than other architects.

## ENDNOTE

1. Preparation: This stage is related to inputs of knowledge and information to the creative process.
2. Incubation: is a method to facilitate thinking that includes a period where no conscious effort is made to solve the problem.
3. Illumination; This stage is actually considered an output and is related to the sudden appearance of the idea.
4. Validation: This stage is when the appropriateness of the solution obtained from the illumination stage is examined and confirmed (Howard, Culley, and Dekoninck 2007).

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