Training in Basic Design Studio: Analysis of Tutor & Novice Students Interactions, Using Linkography Method

Shima Mehrad [a], Omid Dezhdar [b,*], Gholamreza Talischi [c]

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

[b] *Department of Architecture, Hamedan Branch, Islamic Azad University, Hamedan, Iran*

[c] *Department of Architecture, Faculty of Art and Architecture, Bualisina University Of Hamedan, Hamedan, Iran*

Abstract

In the basic architectural design studio, due to the student being at the novice level and their unfamiliarity with the nature of design knowledge, there are always challenges in the field of learning and teaching. The most important educational activity in the architectural design studio that increases the design ability of novice students is the interaction between tutor and student, around solving the design problem. Therefore, studying and analyzing the correction sessions held by the tutor while solving the design problem can provide complete information about the quality of interactions and the factors affecting them. This set of information can be useful in future studies to facilitate design education for novice students. one of the most recent and also most accurate methods to analyze the way designers think in the situation they face with a design problem is to analyze design sessions using the Linkography method. In this method, what happens aurally during the design critique session between the tutor and the novice student is written down and the resulting text is coded using the FBS method. In FBS coding, codes are design problems and their relationship to each other defines design processes. Linkography is a method that converts the conceptual connection between codes into visual diagrams.in the current research, the interactions of tutors and novice students in three basic design studios have been analyzed and reviewed using the Linkography method. In the next step, citing the results of the analysis of Schön's theory as the most complete written research in the field of studio education, the role of the tutor in a successful studio has been identified. the results demonstrate that to establish successful interactions between tutor and student in the basic design studio, playing the role of the coach by the tutor is necessary. The tutor in the position of coaching has special behavioral characteristics that are introduced in the final research results.

Keywords: Design studio, Tutor-student interaction, Linkography, Desk crit

1. Introduction

The core of education in the design studio is the interaction between tutor and student. These interactions are formally done at the desk crit. Donald Schön provides one of the most complete descriptions of how to teach in a design studio. The results of his research introduce "interactions with reflection" as the main factor in building design knowledge in the studio (Schön, 1985).

These interactions focus on the design problem. In the basic studios, due to the low skills of students and unfamiliarity with the teaching method, interactions are often fraught with challenges.

In the present study, reviewing the research literature and referring to Schön's theory as the most complete written research in this field, an attempt has been made to analyze the quality of interactions with the help of the Linkography method. Linkography is the most accurate and up-to-date method of studying the way designers think.

This study aims to provide a complete description of interactions in the studio, reveal its hidden aspects, and determine the role of the tutor in interactions.

Achieving this goal can pave the way for further studies to improve design education for novice students.

2. Problem Statement

There are always challenges in the teaching/learning process in basic design studios. The different nature of design knowledge has led to different teaching methods in the studio. The studio is a learning space with practice in which students perform design projects under the guidance of a tutor. The studio is a learning environment with tasks and practice, so understanding the teaching and learning process requires a comprehensive understanding of the activities performed there. An important part of training in design studios is through various interactions between tutor and student. Researchers believe that the manner and quality of tutor-student interactions affect the process of design education.

In basic studios, teaching and learning are far more complicated. The novice student is not familiar with the nature of design knowledge and how to achieve it. On the

other hand, it is more difficult for tutors to teach in beginner studios. These conditions make interactions face challenges. This study aims to provide a complete description of interactions in the studio, to reveal its hidden aspects, and to determine the role of the tutor in interactions.

Research questions include:

What factors are effective in the interaction between the Tutor and Novice Student?

How is the role of the tutor in interaction with the novice student?

3. Studio Education

The design studio is the first and possibly the most important educational setting where architectural design students enter. Differences in how to handle a design project are trained and acquired by students makes it a unique learning setting (Rogera, 1996).

The design studio has been described as "the distinctive holy-of-holies of architecture education". It is also the place of professional socialization and enculturation, that is, the studio where the ethos of a profession is born. Many students spend most of their time in the design studio, where they work, study, eat and even sleep. The design studio traces its origins back to the concept of apprenticeship in the atelier and transformed during the Ecole-des Beaux-Arts and the Bauhaus until it evolved into its present form (Zandimoheb et al., 2020).

Traditionally, the studio has been considered a place for individual design work and one-on-one mentoring between an instructor and student.

studios are no more than a physical atmosphere of a class that is based on practice and requires a comprehensive understanding of what is done in the process of learning and designing (Dezhdar, 2013). In general, educational tasks in studios are not limited to lectures and include a range of activities such as supervision, presentation, desk critic, peer learning, and judgment (Saghafi, 2010). Architectural design studios are based on some principles which are mostly derived from learning by practice (Schön, 1985). A studio is a practice-based learning atmosphere wherein students work on a design project supervised by a tutor. Designing sessions are held two or three times a week for hours in which students interact with tutors and their peers.

The most common dialogues between tutors and students are one-to-one critic for 15 to 30 minutes. Drawing and talking are two parallel ways by which the two sides interact, which is called the design language (Schön, 1983).

Literature: design studios are based on design training. The literature covers a range of studies that are briefly examined below: studio style (Salama, 2007), knowledge transfer in studios (Heylighen et al., 1999), studio activities (Wendler & Rogers, 1995), training strategies (Quayle, 1985), formal examinations (Dinham, 1987), emotional and psychological issues (Austerlitz & Avot, 2007; Ochsner, 2000). However, with an exception of studies by Schön and Dinham, other studies fail to provide

a comprehensive analysis of the interaction between tutors and students.

4. Student-Tutor Interactions

Undoubtedly, a major part of the educational practice in design studios pertains to interactions between tutors and senior students. Researchers claim that the nature and quality of these interactions significantly affect education. Schön suggested a comprehensive analysis of the quality of these interactions upon which the activities are based. For him, communication is the key to developing and expanding student design ability. His crit desk is the most comprehensive embodiment of Vygotsky's zone of proximal development where knowledge acquisition occurs when learners gain the skill to do in practice what they formally did with the help of others.

Schön precisely delineates that the studio tutor uses two ways of illustrating reflection-in-action for the students:

1. Language of designing
2. Language about designing

The language of designing is the same as the language of Drawing and talking which are parallel ways of reflection in design. The language of designing is the language of architecture; a language game that the tutor devises for the students and in this way reflects his level of expectation of them. When the tutor makes use of language for design, his speech is quite general; not only for the moment of designing something. This language is about design; a meta-language that the studio tutor utilizes to describe some of the characteristics of the present process and on the other hand introduce and illustrate reflection-on-action to the students.

Therefore, the foundation of studio education is on the fact that architecture professional artistry is learned only through participating students in doing design process. Schön provides two major reasons for this issue, i.e. participating students in the initial stages of design work:

1. All basic and important points of design cannot be said; they are abstractly tacit and hidden in the performance and their verbal representation is impossible.
2. In many cases, expressing these rationales is useless; since it seems that it will be more efficacious in terms of educational outlook if the student himself is compelled to experience and internalize an event.

Student-tutor interaction is a kind of communication between a novice and an expert. Webster (2008) redefines the framework on reflection in design studios. He challenges Schön's conception of tutor-centered learning atmospheres. Indeed, architecture is a complicated discipline that needs further exploration to be fully understood. Students experience a full dimensional understanding of explicit and implicit architecture that helps them become experts.

Schön conceptualized a global model of reflective practitioners, but that's not all and design studios need further studies. Schön considered two major issues:

A) Reflection-in-action and reflection in interaction
B) Critical analysis in design studios that allow novice learners to develop expert reflective capability.

About 30 years ago, it was Argris (1981) who defined design studios as a tutor-oriented learning atmosphere in which students have to decode tutors' mysteries. A student feels like being involved in a game in which the tutor tutors everything in the studio and the student wonders how he can develop such tutors.

Recent studies have adopted a broader perspective on the analysis of design studios and seek to replace its educational atmosphere with a more productive one. Bose (1997) studied this educational atmosphere interview with tutors and coaches in design studios in an attempt to challenge traditional learning systems which are characterized by one-sided training in which the tutor transfers knowledge and the student receives that.

In 2012, the American Institute of Architecture Students (AIAS) in a special issue entitled studio Culture drew attention to the implicit social area of the studio (Koch et al. 2012). They consider the common culture in the studios to be mysterious and ambiguous. The student's success in this context depends on understanding and acceptance of the tutor's language and references. Monson (2014) discusses the unspoken values in the studios. He considers the studio environment as effective in not updating the students' values. Manson expresses that although students work in seemingly participatory, problem-based areas, this personal autonomy - exercised by a prominent architect (who has emerged as a tutor) - is ongoing.

5. Schön Text Analysis: Interaction Steps in the Studio

In analyzing Schön's description, four highlighted areas in describing relations and interactions between the tutor and student can be extracted: 1. Reflective conversation with design situation, 2. Telling, Listening, Demonstrating, and Imitating 3. The willing suspension of disbelief, 4. Reciprocal reflection in action (Dezhdar, 2013)
In each of the above-mentioned issues complicated levels of roles and interactions between the tutor and student can be diagnosed:

5.1 Reflective conversation with design situation

At the beginning of the design process, the student engages with a design problem. During work time, the studio tutor has some meetings with the student and listens to his words. Schön assumes some roles for the studio tutor: a) diagnosing the problem, b) critical reflecting on possible student's framing of the problem, c) reconstructing that framework
This is done by the practice that Schön names as an on-the-spot drawing experiment. By the use of the two abovementioned roles, the tutor starts an interactive conversation with the design situation and attempts to exhibit it (Schön, 1985). He explains that in this reflective conversation with the design situation, the studio tutor creates conditions that may be potentials for successive reflections; this, in turn, may lead to creating an unexpected problem that requires subsequent reflections

for its solution. Quality of how the tutor displays this process will be explained in the next section.

5.2 Telling and listening, demonstrating and Imitating

Schön entitles the studio tutor to an artist and justifies it as: he knows the possibility of organization and regulating a complicated setting by the use of practices and regulations for the existing situation and likely future situations (Schön, 1985). The tutor is not only in the part of a designer in the studio but as an announcer. He analyzes students' problems, criticizes their performance, asks some questions, and provides them with recommendations and regulations for later practices (Schön, 1985). When the tutor is speaking, the student's task is to listen to understand and implement it in his work (Schön, 1985). Schön uses the "operational attention" term for this type of listening.

Student must be ready to implement whatever he hears; especially in a way that the tutor wants (Dezhdar, 2013). Observing the tutor's performance and listening along with operational attention can encourage students to model and obeying the tutor's performance and speech (Dezhdar, 2013). According to Schön, obeying doesn't mean imitating whatever is observed, but it is a construction process in which students must formulate an idea that is essential for the tutor and display it in their performance (Dezhdar, 2013). He uses "reflective imitation" for describing this process. In this reflective imitation, the student tries to find a way that best adapts his work. For Schön such a process of reflective imitation may be divided into several "moments". He emphasizes that they are not clearly distinguished from one another in real practice (Schön, 1985). These levels include:
1. Comprehending what is important in the tutor's performance.
2. Doing in the same as the tutor and substituting models in a way that student as an observer change into a producer of action.
3. Student reflection on his performance. By reflecting on his performance and the tutor's, the student is looking for producing something in action which is essentially intertwined with the tutor's action. 4- Internalizing the tutor's performance and dominating it (Monson, 2014).
Teaching designing essentially begins with a paradox: asking students to reflect and act as an architect; while it is conspicuous that students are not capable of doing so. Indeed, they sometimes find the whole experience of the studio mysterious. In this situation the tutor cannot help them since he diagnoses that the students initially do not understand fundamental concepts; on the other hand, these concepts cannot be expressed verbally because basic design concepts are just learned practically and around design experiences (Dezhdar, 2013).

5.3 Temporary suspension of beliefs

A Double Paradox is in progress in the studio milieu: on the one hand, the student doesn't know what he needs to learn, but on the other, the student is responsible for his learning, and only when he starts doing can achieve self-

teaching. Schön declares that this paradox can be dominated by a special mechanism and thus he inaugurates willing suspension of disbelief.

Because the tutor cannot convey his understanding and skillfulness except through explanation and illustration, students are asked to act on a set of actions under the guidance of the tutor. After doing these actions and providing suggestions on the part of the tutor, students can gain authentic experiences. Gradually students begin to understand essential elements in the tutor's performance and learn to have wise choices and make correct decisions.

Schön says that students are requested to temporarily leave whatever they know and respect. He delineates some consequences for this willing: a) confusion and ambiguity of the students. Because they are asked to put their background reflections away and instead, reconstruct them with the tutor's assistance. b) Dependence on the tutor and hence experiencing a reduction in his self-confidence and qualities. These two prepositions can build a situation in which the student feels a lack of self-confidence and quality and sees himself as a person who swims in unknown seas and without any control or perception. A guaranteed training process requires the students to adequately trust the tutor's abilities. Schön claims that those students who have a higher sense of self-efficacy do not feel a threat from the tutor and vice versa, those with a lower sense of self-efficacy encounter some problems in dealing with this willing suspension.

5.4 Reciprocal reflection in action

Schön assumes a bilateral nature for interaction between the tutor and student and calls it "reciprocal reflection-in-action". That is, the tutor: a) speaks, b) gives a model, and the student: a) listens actively, and b) constructively imitates.

The tutor is not only engaging in the process of reflective conversation but reflecting on the students' conception using the students' performance as evidence of their understanding. On the other hand, students try to understand concepts illustrated and expressed by their tutor and look for translating whatever they have learned in his performance. In this perspective, every performance is an experiment that is representative of the student's recognition and translation of what he has seen or heard in his performance. This reciprocal interactive reflection will be successful only when it gains its convergence in meaning (Dezhdar, 2013).

Schön believes that succeeding convergence in meaning demands two conditions: a) environment and context must encourage students to undertake action, b) the process of telling and listening, demonstrating, and imitating must fit into a scaffolding of reciprocal reflection-in-action. Schön's description illuminates the most fundamental and in turn, challenging components in the educational system tradition of design studios.

Designing instructors and professional architects are seen as professionals who teach architectural designing through learning methods and doing. The student has already started designing before even knowing how to do so; because nothing can be said to him before doing designing. In this process, the tutor has the role of a guide for the student. This issue is the main base in the construct of studio education (Dezhdar, 2013).

6. Tutor's Educational Roles in Schön Text

Like any other person, tutors need to develop professional as well as individual skills and promote their perception of personal values regarding their educational roles. They have received no formal training for this and need to learn by practice which is determined by their personal experience, knowledge, and aptitude (Goldschmidt, 2010). Quayle (1985) classified teaching roles into a list of six items which was later consolidated by Goldschmidt into three profiles: source of expertise/authority, coach, and friend.

6.1 Tutor as the source of expertise/authority

The tutor knows what the student seeks to learn and transfers the knowledge. In such a system, the educator has authoritative control over the learner. Therefore, it is much easier for the student to indulge in and follow the educators' instructions without fully understanding them. The student may also take in these instructions with no reflections. Koach et al. (1991) and Dutton (2012) warn that tutors' authority significantly challenges learners' critical thinking.

6.2 Tutor as a coach

The student has potential or implicit knowledge and the tutor is expected to help develop and turn them into opportunities. Schön (1987) argues that this role helps establish an atmosphere of dialogue between the tutor and the student from which positive outcomes arise (Robin, 2015). Schön believes that the role of the coach by a tutor at the studio can lead to proper and constructive engagement. Figure.1

6.3 Tutor as a friend

The tutor encourages students and helps develop professional culture and socialization to expand learners' ability in design (Goldschmidt, 2010). We should bear in mind that tutors have no set of unique and predefined characteristics but we can generally classify them based on their traits.

7. Novice Students

According to the model proposed by Lawson (2004) and later by Dorst (2009), and considering the skill acquisition model of Dreyfus Brothers for different levels of growth in design ability, a novice student is someone above the beginning level and the public has this ability to perform routine acts (Cross, 1995). At this level, the individual has no training for designing and mostly relies on imitation.

A junior student of architecture is a beginner with a primary knowledge of designing that collects information

while practicing designing. For him, collecting information may replace the act of designing. A novice rarely offers a offers a satisfactory step-by-step design (Cross, 2004).

may spend a great deal of time on defining a problem and

He always looks for opportunities to learn, while an expert designer is innovative and has a holistic perspective on designing (Cross, 2004).
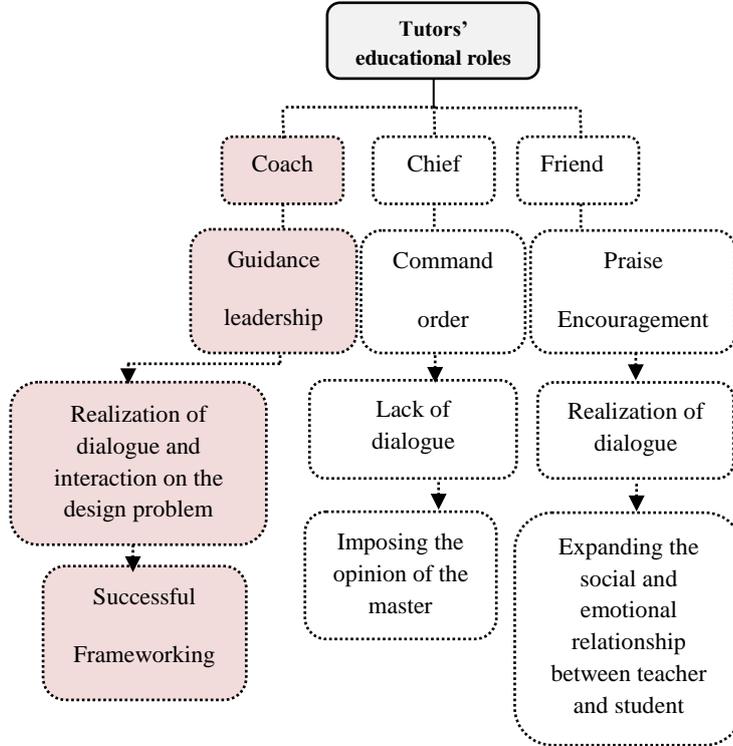
Fig. 1 Tutor's educational roles According to Schön's theory analysis

Schön affirms that a novice student in the studio can behave in two ways:
The first behavior is the result of trusting to tutor. In this case, the student is paying attention to the tutor's words and behavior and tries to imitate along with contemplation. As a result, with the tutor's guidance, the student gradually succeeds in solving the design problem.

The second behavior is the result of untrusting to tutor. In this case, the student does not accept the tutor's guidance and imitates the tutor because of fear of punishment. As a result, students cannot frame and solve the design problem.
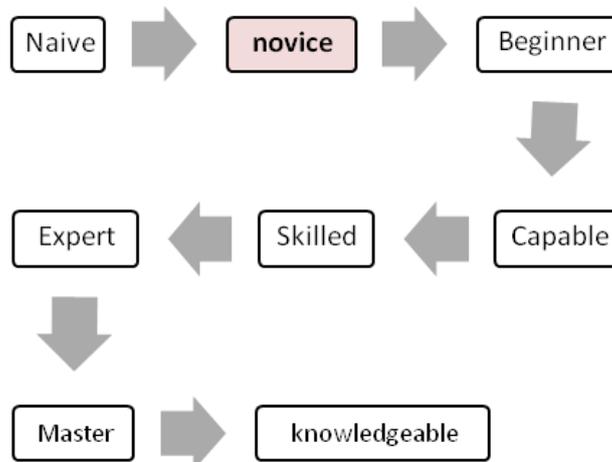
Fig. 2. Lawson & Dorst models for different levels of growth in design ability
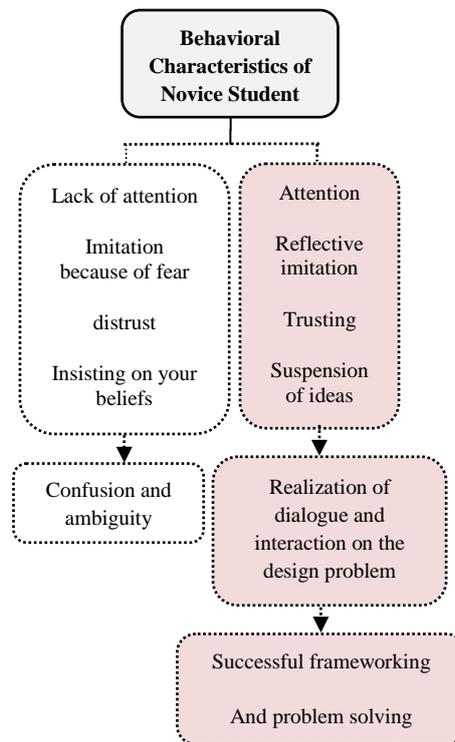
Fig. 3. Behavioral Characteristics of Novice Student According to Schön's theory analysis

8. Research Methodology

 Different approaches have been suggested for studying the activities of designers, including interviews, behavioral analysis, and analysis of design sessions. Analysis of design sessions is the most modern approach that is used in the present study. Here, a real sample of the process is analyzed. Any problem-solving session in a lab can be analyzed by this method. The analysis of designing sessions helps identify designing activities, cognitive models, and knowledge structure of designers and also contributes to recognizing perceptive dimensions of designing (Rahimian, 2013). Textual data from analysis stations are converted to statistical data and graphic charts using Linkography. These are further studied to reveal designers' reflections during design sessions.

8.1 Linkography

Linkography is a structural practical method to analyze design ideas as a network of relations. It was first proposed by Goldschmidt (1990) and later adopted by other scholars.

A Linkograph visualizes design moves and how they are related to each other (Al-Hammadi, 2020). A move is an action by a person that changes their design. If two moves are conceptually related to each other in a route, they will bind to each other. A typical design session includes hundreds of moves and their relations. The moves are represented on an axis in chronological order, and diagonally connect links of each pair, forming a graphic network. The highest point of a diagonal link is called the link node (Goldschmidt, 2016). The spatial position of a link node is a function of two moves during the session and shows the distance between the two moves. Schmidt proposes two types of links: backward and forward.

Backward links refer to earlier dialogues and ideas, while forward links are created on backward links and can be identified once the Linkograph is completed. These links show designing moves that convey an idea and innovation. Sessions with the highest number of forwarding links indicate higher innovation and creativity (Ken et al., 2006).

Similar to direct networks, any move in the Linkograph can be linked to peer moves. The session design text includes independent concepts as a move in the Linkograph. Then, the links are created based on conceptual relations. Sum of design moves and conceptual links form the structure of a Linkograph (Pourmohamadi, 2011).

An analysis of the structure of a Linkograph can show design process features and factors that determine its success or failure.
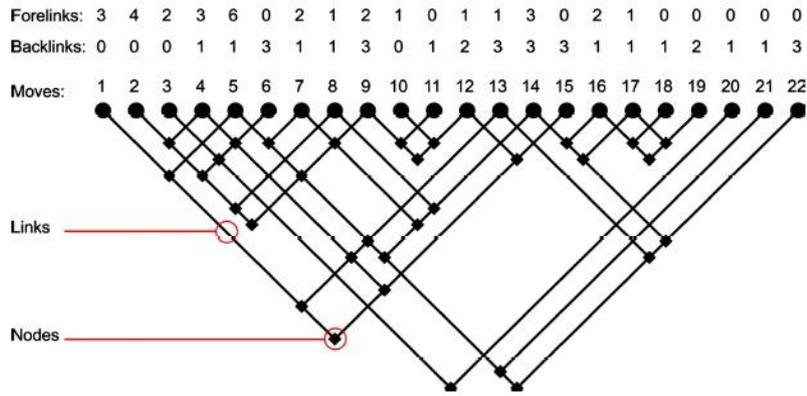
Fig. 4. Behavioral An example of a Linkograph showing backward and forward links in each movement

8.2 FBS Coding

In 1990, Jane Gero introduced a coding model similar to Linkograph in which codes are design problems that can be used in different areas such as architectural design. It includes 7 codes (R, O, D, S, Bs, Be, F) and the relationships between codes express concepts in the design process (Jahanbakhsh, 2018).

Table 1
Introduction of FBS codes and the concept related to each code

FBS codes	codes concept
R	Basic design needs and information
F	Desired function
Be	Behavior that the designed structure
Bs	Behavior that will have a designed
S	Proposed structure and idea
D	Definitive structure recorded
O	Out of coding range

He also proposed a model for the relationship between these codes that help identify all design processes (Figure 5).

The processes are explained below:
1: formulation
2: Conceptualization
3: analysis
4: evaluation
5: registration of the idea
6: a review of the structure
7: a review of the behavior
8: a review of the function

Understanding the relationship between these design processes can help us get a better idea of the whole process and to find out if it can be solved or not. If these processes are related to understanding the problem, it means that the two sides are involved in defining and identifying the problem. But if the processes are related to creating ideas and offering solutions it means that the two sides have been able to create ideas. The number and frequency of codes and FBS processes are time-consuming and need careful attention, which is mostly done by software.
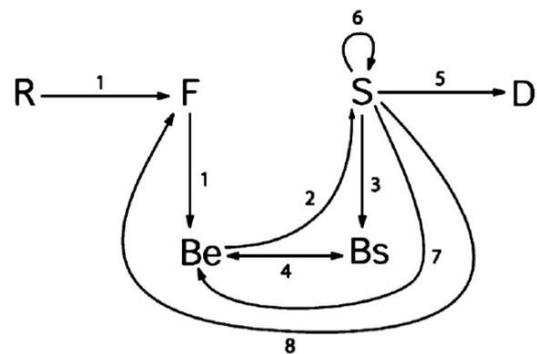
Fig. 5 Behavioral An example of a Linkograph showing backward and forward links in each movement

8.3 Linkoder software

Quantitative analysis of design sessions is a costly method regarding time and resources. One possible way to reduce the time and cost of such research is to use the software to perform some parts of the process automatically.

In this regard, Pourmohammadi (2011) designed the Linkoder software to save time in preparing protocols for analysis. This software is based on the FBS method (Pourmohammadi, 2013). Two sets of data are obtained from the sessions. One set is related to codes (FBS) and the second set is related to linkographs which are obtained from linking codes. The initial data of each design session includes the information encoded based on (FBS) and is linked, which must be saved as an (XLS) file and entered into the Linkoder software. Undesigned units are removed from the entire code and are not checked. This file is entered into the Linkoder as input data and the output information is obtained in both textual and visual forms.
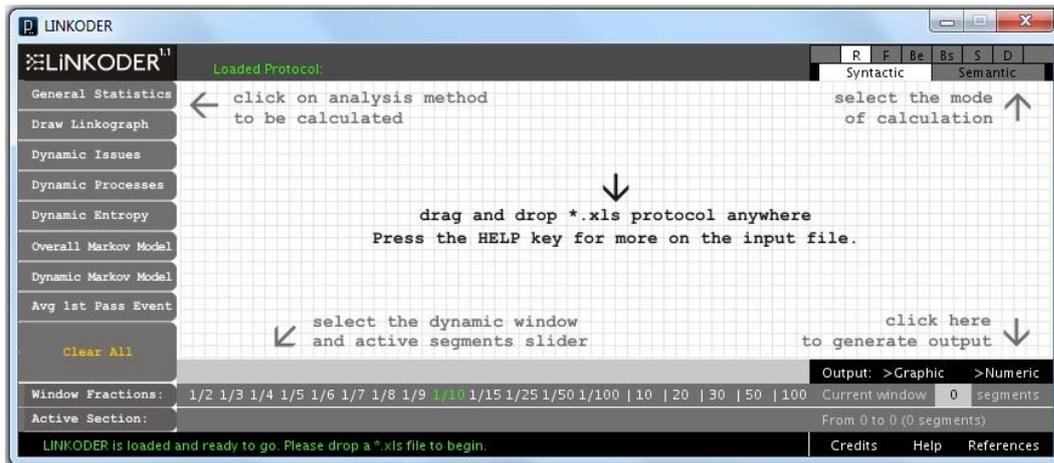
Fig. 6. Behavioral An example of a Linkograph showing backward and forward links in each movement

9. Research Process

The present study aimed to "explain a model for the interactions between tutor and novice student in the basic architectural design studio using the method of Linkography". According to the title of the research, the samples needed to be novice students present in the basic design studio. Therefore, the statistical population of first and second-year students of Architectural Engineering (2017) was considered Bu Ali University of Hamadan. From the courses of these students, three basic design studios with three different tutors were selected. To select the basic studios, we referred to the Text syllabus and the explanations provided in it. The researcher attended all the sessions of these studios and the conversations between the tutor and each student were recorded and written. The text of these students' conversations with the tutor was encoded by the FBS method. The codes are classified as XLS files and entered into Linkoder software. The outputs obtained from the software include two categories of statistical and graphical information.

Using mathematical relationships and statistical information, three indicators can be identified for each student. Problem Solving Index (PS), Link Index (LI), and Critical Motion Index (CM). Evaluating these three indicators for a student's corrections determines how successful the student is in solving the design problem. On the other hand, solving the design problem has been the main topic of tutor-student interactions. To determine the role of the tutor in interactions, the average of student indicators in each studio is calculated, and based on this, the successful studio is determined. Finally, according to the results of the analysis of Schön's theory and the behavioral characteristics of the tutor in the successful studio, the behavioral characteristics of the tutor and the novice student in the interactions are expressed.

10. Findings Report

and graphical output of Linkoder software introduces different indicators about a design session. Here, according to the purpose of the research, the indicators that were used and also the results of their analysis are explained. Statistical information obtained from LinkedIn includes Sections and Links that can be used to calculate other indicators such as the Critical Movement Index (CM), Link Index (LI) and Problem-solving Index (PS) Achieved. Link Index is the ratio of the number of links to the number of sections, which is one of the important indicators in measuring the productivity of designers. The high LI Index during a conversation indicates the continuity of the conversation and the existence of a single topic. The CM Index is related to critical movements. Critical movements are design movements that contain an important idea or critique of the design process. The frequency of these movements during a design process indicates a rich interaction of ideas and creativity. The PS Index is also related to problem-solving and is the ratio of the sum of the problem area codes to the solution area codes. So, the larger the PS Index, the more talk there is about the problem, and the smaller the PS Index, the more solutions are offered.

$$PS = \frac{F+R+Be}{Bs+S}$$

The small PS index means that the parties to the dialogue have been able to move beyond the scope of the issue and move towards a sectoral framework. Also, the large PS index means that the parties to the dialogue are stuck in the problem area. Visual information also includes lithography. A linkograph diagram includes the relationship between the codes as well as the effectiveness of each part of the interaction in the design process. In linkograph network analysis, movements that have more forward and backward links are called critical movements (CM). The higher the number of forwarding links, the more critical the unit. To show the working method, the analysis of the information obtained from a student is presented.

11. Case Study: Analysis of a Student's Statistical Information

Here, to determine the analysis process and how to obtain the results, the information obtained from the analysis of the design sessions of one of the students is examined. This student has participated in 13 correction sessions out of 15 studio sessions. The average duration of each correction is 15 minutes and in total, the student's conversation with the tutor about solving the design problem was recorded as 2 hours and 45 minutes. The text obtained from the student critique sessions with the tutor consists of 97 sections, of which 56 are related to the tutor and 41 are related to the student. Accordingly, 57.7% of the conversation is related to the tutor and 42.3% of the conversation is related to the student. Based on this information, the level of participation of each tutor and novice student in this interaction is almost equal. According to Schön's text analysis, it can be concluded that the relative equality of the percentage of conversation in this interaction shows the role of guidance and coaching of the tutor.
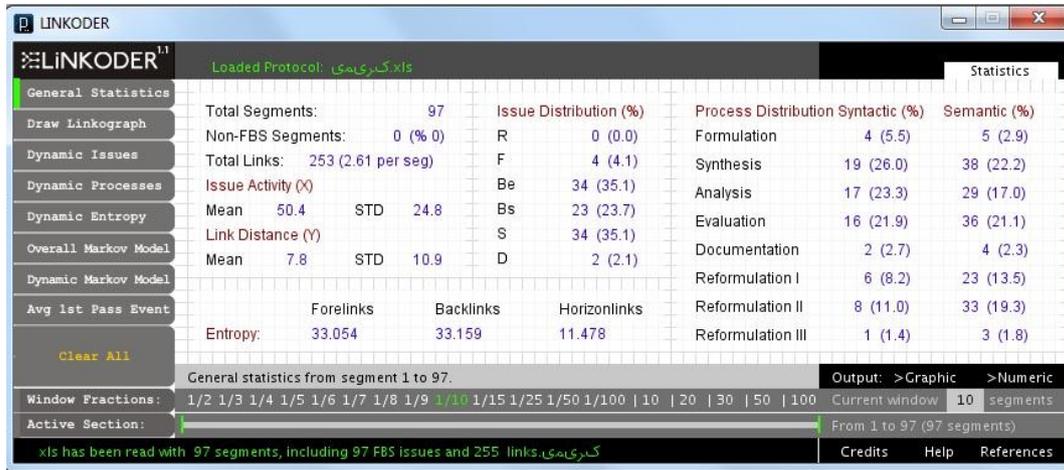
Fig. 7. Behavioral An example of a Linkograph showing backward and forward links in each movement

statistical outputs obtained from Linkoder software show that the Index of links is 2.61. The high level of this Index confirms the high coherence of the conversation, the coherence of the concepts, and the very good interaction between the tutor and the student.

$$LI = \frac{\text{Total Links}}{\text{Total Segments}} = \frac{253}{97} = 2/61$$

Here, the problem-solving index (PS = 0.66) is 0.66, and the low level of this Index indicates that interactions are out of the problem, and dialogue is presented along with presenting ideas and solutions.

$$PS = \sum \frac{R + F + Be}{Bs + S} = \frac{0 + 4 + 34}{23 + 34} = 0/66$$

In addition to the results obtained from the analysis of statistical information, the results are also obtained from the graphic diagram. The following figure shows the graph of student corrections.

The resulting graph has many dense triangles. This reflects the focus of the ideas presented during the design. In addition, the chart below shows the critical movements with the number of links above 6 (CM6). The presence of multiple critical movements in this graph represents a rich process of ideas and shows the positive growth of interaction.
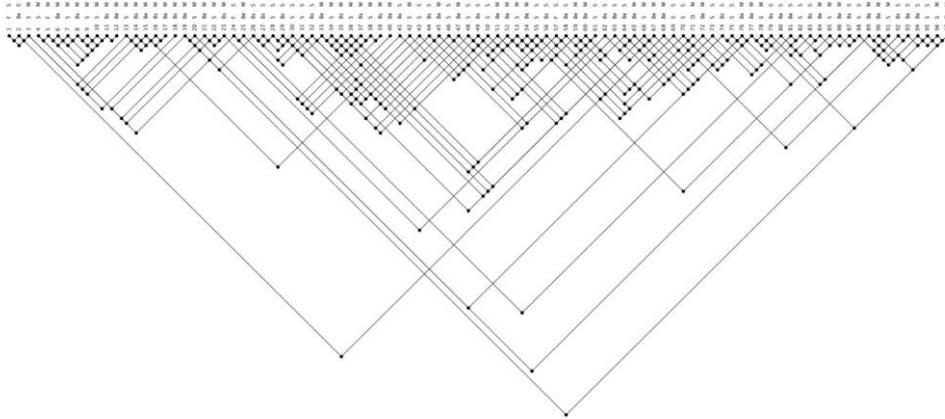
Fig. 8. Linkograph diagram obtained from student correction sessions
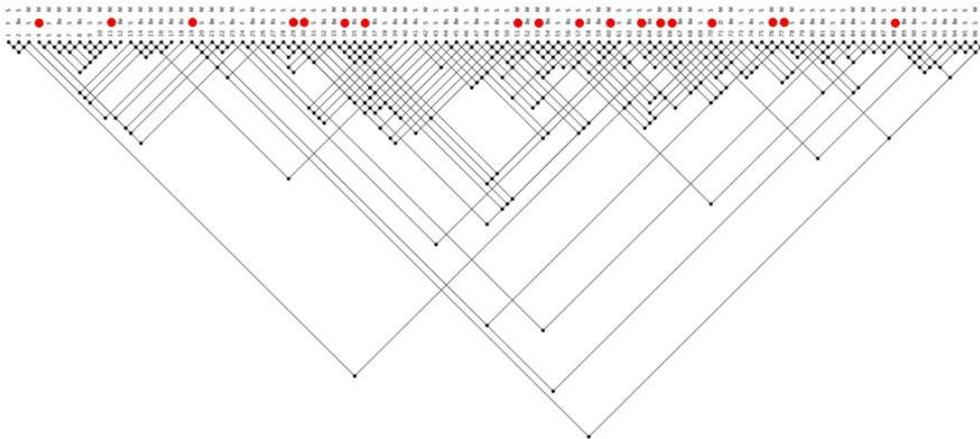
Fig. 9. Critical moves with a high index of 6 links (CM6) in the Linkograph chart

12. Discussion and Conclusion

As explained in sections 9 and 10, the statistical population consisted of three basic design studios. The corrections of each student in these studios were reviewed using the Linkography method and Linkoder software. For each student, according to statistical data obtained from Linkoder, three indexes including Problem-solving Index (PS), Link Index (LI), and Critical Movement Index (CM) were obtained. Then, to determine the success rate of interactions in each studio, the average of these indicators for each studio were calculated.

The results demonstrate that studio B has the average link Index (LI = 2.7), the average critical movement Index (CM = 12), and the average problem-solving Index (PS = 0.4). The higher LI and CM indices and the lower PS index in this studio compared to the other two samples, indicate the greater success of interactions in studio B. After determining the successful studio, to identify the role of the tutor and analyze his behavioral characteristics, refer to the text of Schön's theory. Schön's theory is the most complete written research on the description of education in the design studio. As mentioned in Section 6,

the findings of Schön's text analysis show that the tutor in the studio with the role of a coach can guide the student and facilitate his learning. In such a situation, there will be a coherent dialogue between the tutor and the student about the design problem. The high average for Link Index (LI) in studio B compared to the other two samples indicates the high coherence of the conversation and the coherence of the concepts raised during the interactions, which can confirm the role of the coach for the tutor.

According to Schön's theory, if the tutor creates an equal opportunity for dialogue in interactions, does not deal with the student from a position of power, and does not try to impose opinions, the student will have the necessary confidence to express opinion and creativity. In studio B, the high critical movement Index (CM) indicates the presence of these behavioral characteristics in the tutor. For this reason, most students in the studio have been able to have design movements that contain ideas and creativity. This reaffirms the role of coach for the studios tutor.

On the other hand, according to Schön's theory, the role of coaching by the tutor causes the student to understand the dimensions of the design problem and provide a

framework. In this situation, the student is not caught in the trap of the design problem and can start designing by crossing the scope of the problem. In studio B, the low problem-solving Index (PS) confirms the success of the tutor in this field.

In summarizing the results obtained from the analysis of indicators of studio B (successful studio in the field of interactions) and also citing the results of Schön's theory analysis, it can be concluded that the role of the tutor to establish a successful interaction with the novice student is the role of coaching. The following behavioral characteristics are remarkable for a tutor playing a coaching role:

- Playing a guiding role during interactions
- To avoid imposing personal opinions on the student
- Playing a facilitating role for the student
- To reflect on student action
- To predict possible future situations in the design process
- To provide a free and safe space for bilateral dialogue in interactions.

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