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The Effect of Teaching Model of Procedural Knowledge (Based on Oser and Baeriswyl Criteria) on Improving the Design Ability of Architectural Freshman Students

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Abstract

The aim of this study was to implement the teaching model of procedural knowledge in teaching basic design studio courses and to investigate the effect of this teaching model on improving the design ability of freshman students by evaluating their activities as a test of this method. Architectural basic design (I) lesson has been considered as a case study in this research. This teaching model is based on the theoretical foundations of procedural knowledge and the criteria that determine a teaching fmodel in terms of "Oser and Baeriswyl". The method of the present study was quasi-experimental with a pre-test, post-test, follow-up test design with a control group. The statistical population included first-year undergraduate students of architectural engineering in universities of Hamadan province. Among them, 30 students of architectural basic design (I) lesson of Islamic Azad University, Hamadan Branch were selected as a sample by available sampling method, but were assigned randomly. The data collection tool was a researcher-made test to measure students' performance, which was approved by experts. Data analysis method using descriptive statistics (mean, variance, standard deviation, etc.), inferential tests (covariance and its assumptions) and t-test using SPSS software (2021) version. Findings showed that teaching based on teaching model of procedural knowledge can through increasing learning motivation, recall past learning and create meaningful learning, facilitate learning flow, increase cognitive involvement and learning stability, develop design schematics and improve problem-solving skills, Improves the design ability of architectural freshman students in the design studio of architectural basic design (I).

Keywords: Design ability, Procedural knowledge, Declarative knowledge, Teaching model, Architectural basic design (I)

1. Introduction

Design requires a complex mental process of the ability to access large types of information, to integrate them into a coherent set of ideas, and ultimately to create a realized form of ideas. According to Lawson, the realization of design requires considerable knowledge and skills (Lawson, 2006: 17). The design ability has different dimensions of knowing. These dimensions include declarative and procedural knowledge (Kalami & Nadimi, 2014). Declarative knowledge involves "Knowing That", "Knowing Why","Knowing When"(Glover & Browning, 2002) and Procedural knowledge involves "Knowing How" to perform skills (Laria, 2008). The introduction of design as a skill in Lawson's thought shows that procedural knowledge is used in the design process (Goudini, 2020: 32). In his article "More Knowledge, Better Design" about the importance of architects' knowledge, Davies believes that those architects who benefit from more and deeper knowledge also have more design ability (as cited in Sedaghati, & Hojjat, 2019:95). The design ability has growth stages. According to the design ability model developed by Lawson and Dorst (2013), many freshman students of the architectural basic design (I) are in the naive stage of design ability. At this stage of the development of design ability, the designer has normal and daily design activities and can not be promoted to the next stage without proper training (Talischi et al., 2012). It is difficult for a freshman student to understand the design studio. One of the most important reasons is that the student in high school has no academic experience of the design process and is faced with a new language that is different from what he used before (Kiessel & Abbasoglu, 2008; Hojat, 2004). The first-year of students entering the school of architecture includes the processes of stepping into thinking, creating and expressing, which takes place after high school and education based on memorization and repetition (Ustaomeroglu et al., 2015). The method of teaching basic design studio courses that are offered in the early years of learning is of great importance and any shortcoming in the quality of teaching these courses will have a direct impact on the design ability of architecture students in design courses (Mehdizadeh Saradj & Farsi Mohammadi Pour, 2012). Cross (2006) believes that design education can be

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a successful and reliable tool for developing design ability. However, conventional training of basic design studio courses does not have the necessary efficiency and leads to shortcomings in various dimensions (Moosavi et al., 2019). Therefore, it is necessary to prescribe the optimal training method to facilitate the development of freshman students' design ability (Talischi et al., 2012:19). Design Research in recent decades has witnessed the development of studies on the nature of design ability. Therefore, studies on educational models based on describing and explaining the growth of design ability are being formed and limited. Despite numerous studies in the field of design ability, we rarely see an educational model that, in terms of recognizing the nature of the content of education and the type of knowledge it discusses, effectively teaches basic design studio lessons in the early years of learning. The present study seeks to fill the research gap related to the effective training of freshman students in basic design studio courses that learners need more in the next semesters and design courses. Therefore, this study was conducted with the aim of implementing the teaching model of types of procedural knowledge in teaching basic design studio courses and investigating the effect of this teaching model on improving the design ability of freshman students. The course of architectural basic design (I), which is one of the basic design studio courses, has been considered as a case study in this research. This course is offered in the early years of learning and aims to guide the freshman student of architecture to the threshold of design ability. The teaching model used in this research is based on the study of procedural knowledge and determining criteria of a teaching model according to Oser and Baeriswyl, which in fact forms the theoretical foundations of the present study and hypotheses Research is based on them. In this model, the process of teaching procedural knowledge, including "pattern recognition", "action – sequence" and " heuristic procedures ", is shown. This study has examined the following hypotheses according to the mentioned purpose:

1) The teaching model of procedural knowledge of "pattern recognition" affects improving the design ability of architectural freshman students.

2) The teaching model of procedural knowledge of "action – sequence" affects improving the design ability of architectural freshman students.

3) The teaching model of procedural knowledge of "heuristic procedures" affects improving the design ability of architectural freshman students.

2. Research Background

In recent decades, many studies on various aspects of its design ability and nurture have been done by thinkers such as Dreyfuss, Lawson, Dorst and Donald Schön in the field of design research. Many researchers have researched about of the design ability, effective teaching models and its application in architectural design studio. In a study, Talischi et al. (2012) Concluded that a constructive learning environment for architectural design facilitates the development of novice students' design ability. Research results of Haghigi et al. (2019) Showed that integrity and interface Approach (integrated and practical learning of new structures in the architectural design studio) can improve the components of design ability. Mohammadzadeh Chianeh et al. (2020) Concluded that the application of mathematical concepts in design education can enhance students' ability in logical aspects of design. Zandi Moheb et al. (2020) Found that novice students in design learning inspired by the performance of expert architects, convergent and divergent thinking, re+ection in the design process, participation and critique in the activities of design studio eventually come up with ideas, create space and make schemas. In this way, individual abilities to construct concepts and recognize the design problem are improved. The research of Demirbas and Demirkan (2003) examined the relationship between design academic achievement in architectural design studio based on the four styles of Kolb and concluded that assimilating learners are the most advanced and accommodating learners are the least progressive have had four design stages during the semester. The research results of lawson (2004) show that the design ability of novice designers is highly dependent on the growth of their design schemas. Mehrdoust et al. (2019) in a study concluded that referring to design precedents and understanding its principles and concepts is one of the methods that can help designers and architecture students in solving design problems. The research results of Schön (1992) showed that using design precedents is beneficial , especially in the early stages of design, and increases the ability of designers to solve design problems. Presley & McCormick (1995) have introduced role modeling, coaching, and scaffolding as three aspects of the cognitive apprenticeship approach which oversees the teacher's guidance and assistance to the student in acquiring skills. Collins et al. (1991) found that the cognitive apprenticeship method makes thinking a visible phenomenon and helps the learner to acquire the necessary expertise and skills in an interactive and communication-oriented learning environment. The research results of Sadram (2012) showed that the design freshman students, with an empty mind of how to advance the design process, cannot gain a proper understanding of the design process. He has to go through the path of imitation to be creative in solving the design problem.

3. Theoretical Foundations

3.1. Types of design knowledge from a theoretical perspective

Knowledge is an unstable combination of experts' experiences, values, background information, and insights that providea framework for evaluating and integrating new experiences and information (Davenport et al., 1998). In the field of cognitive psychology, a threefold separation of knowledge is mentioned: procedural, semantic, and episodic (Tulving, 1985, as cited in Goudini, 2020: 32). Among the other classifications that are presented in this field of types of knowledge, its division is under the headings of procedural knowledge, declarative knowledge and images (Moradi et al., 2011: 96). Design is a knowledge-based activity. The study of different types of design knowledge shows that in architectural design, two types of declarative and procedural knowledge are mainly referred to (Kalami & Nadimi, 2014). Oral or written knowledge is known as declarative knowledge (Taylor et al., 2016). This knowledge includes information about facts, concepts and their definitions, structures, principles, a network of concepts and their definitions, maps, events, goals, names of events and their causes, as well as related information (Kahler, 2003). Knowledge that discusses design skills is procedural knowledge (Sahdra & Thagard, 2003). Procedural knowledge is obtained through direct experience and is acquired through practice and doing work (Fontana, 2004). This type of knowledge, which is difficult to transfer verbally to others to the point of impossibility, plays an important role in professional activity and skills (Kalami & Nadimi, 2014).

3.2. Types of procedural knowledge and its relationship with design ability

The design ability is a facet of human cognitive abilities and everyone has some of it, but most professional designers have improved their design ability through training and experience in architectural design studio (Talischi et al., 2012). The design ability has growth stages. Lawson & Dorst (2013) provide a model for the growth of design ability, which includes naive, novice, advanced beginner, competent, proficient, expert, master, and visionary. This model is based on the skill levels that Dreyfuss (2004) describes based on the titles of novice, advanced beginner, competent, proficient, expert (Goudini et al., 2021) Architectural freshman students are in the naive stage of design ability and are expected to be in the novice stages of design ability in their early years of study (Talischi et al., 2012).

In design research literature, the design ability has defined a set of skills that enable designers to handle design activities (Cross, 1990). Lawson (2013) categorizes the design process into five stages that correspond to the skills required by designers in design realization. These five steps are: 1) formulating the design problem; 2) provide a solution; 3) representation; 4) evaluate; 5) Reflection. By breaking down the design process into identifiable steps and procedures, a descriptive model emerged with the goal that, if followed step-by-step, it would lead to more efficient and effective tools for producing high-quality design solutions. Van Dooren et al. (2014) Observing that design educators, as expert designers, often have difficulty in revealing how the design process is performed, argue that the ability to "explicitize" effective design training is essential. They explain that for experienced designers, the design process "is not divided into separate steps and actions, but the design process is an indivisible whole with automatic steps, actions based on normal procedure and moments of reflection and exploration." They usually can not tell you how to do this. They just do it and expect the student to be able to do something they do not yet know how to do, and this is confusing for the architectural freshman students.

Learning complex skills such as design requires knowing and being aware of how to do it. In addition, the method designed by an expert presupposes in-depth knowledge of information in this area, which includes declarative and procedural knowledge and years of experience in solving a variety of problems in different situations. It is illogical and ineffective to expect a freshman student to design these as a precondition for learning (Van Dooren et al., 2014). Declarative and procedural knowledge interact as types of knowledge in the field of architectural design in the implementation stage and during learning. The topics of procedural knowledge are of three types, which include procedural knowledge of "pattern recognition", procedural knowledge of "action–sequence", and procedural knowledge of "heuristic procedures" (Gagne, 1985; Leshin et al., 1992). Understanding the nature and characteristics of the types of procedural knowledge is an important issue that must be examined and identified tocreate the ground for their proper training and transfer. Procedural knowledge of pattern recognition is the knowledge with the help of which people, through learned mental patterns, reach the ability to recognize, classify, compare and categorize things and identify something in the form of mental inference. The stages of procedural knowledge of pattern recognition are mostly non-objective. Procedural knowledge of action–sequence has obvious implementation steps or performance aspects. The implementation of this knowledge can be repeated and the same each time and the change of conditions and situations does not have much effect on its implementation stage (Gagne, 1985:103). In heuristic procedures, by learning the principles of an action or skill, one uses it in other fluid and variable situations and offers various and creative solutions to solve the problem (Leshin et al., 1992:97). Procedural knowledge of pattern recognition, procedural knowledge of action–sequence, and procedural knowledge of heuristic procedures interact with each other in the design process, but they are learned separately in the early stages of learning (Gagne, 1985). Marzano (2010) proposes a hierarchy of procedural knowledge and distinguishes three stages of procedural knowledge: action–sequence, strategy, and process. In his view, action–sequence can be the first stage of procedural knowledge. Action–sequence are steps that the learner can follow by following those steps. The pervasiveness of action–sequence leads to the acquisition of skills that are specific methods for mastering and performing various physical-manual or mental activities. Strategy is a way to select a set of tests needed to solve a problem in the relevant case. Process is a broad category that includes the implementation of a series of action–sequence and strategies to solve a problem or achieve a goal. In this research, recognizing design skills based on types of procedural knowledge and using the related teaching model is considered as a tool that can show the teaching of design process in a more structured and clear way. The types of procedural knowledge and its relationship with design ability are presented in Figure (1).

3.3. Criteria for determining a teaching model of procedural knowledge according to Oser and Baeriswyl

From Oser and Baeriswyl point of view, in order to determine a teaching model, four criteria should be considered. Moradi (2011) presented the basic dimensions of the teaching model of procedural knowledge based on four criteria, which are described in Table (1). The first criterion is to assume a psychological basis for the teaching model. In this regard, cognitive psychology theory and memory theories are considered as the psychological basis of the teaching method of procedural knowledge. The second criterion of a teaching model is that a learning strategy must be defined to explain how learning and change in cognitive constructs. Accordingly, the content of this criterion is related to how to make changes in learners' cognitive structures as a result of learning and acquiring procedural knowledge. The third criterion of a teaching model is that the visible structures of teaching stimulate the basic patterns. In the teaching model of procedural knowledge, five basic patterns that are used in teaching procedural knowledge were selected. The fourth criterion of a teaching model is that the order of the apparent operations of the teaching model must be determined. Order the teaching steps of the teaching model of procedural knowledge of pattern recognition have a separate process from the procedural knowledge of action – sequence and procedural knowledge of heuristic procedures. The reason for this is the different nature of the types of procedural knowledge.

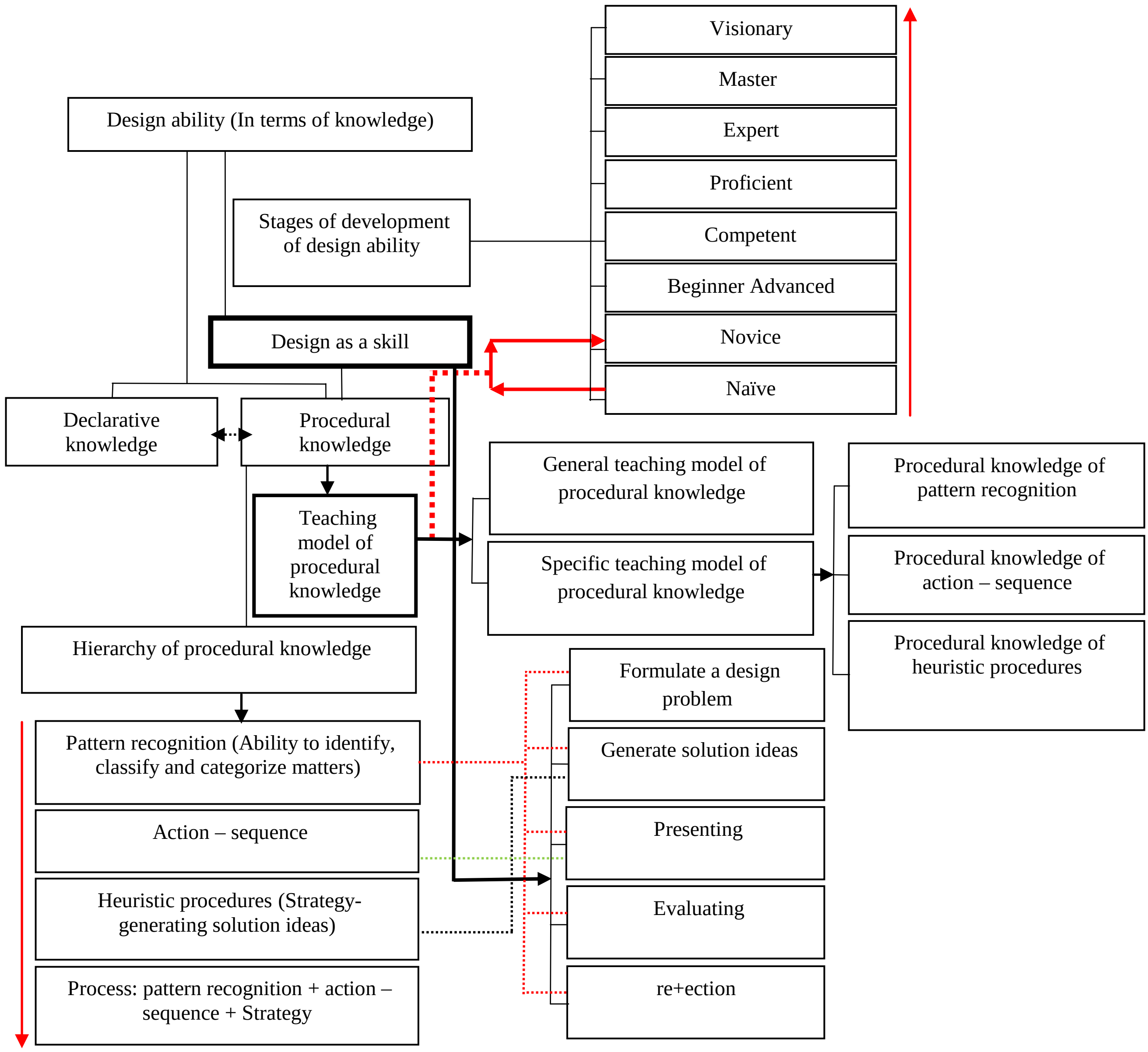

Fig. 1. Types of procedural knowledge and its relationship with design ability, Developed (by Authors)

Table 1
Criteria for determining a teaching model from the point of view of Oser & Baeriswyl. (Moradi et al., 2011)

Basic dimensions of the teaching model of procedural knowledge	Criteria for determining a teaching model
Based on cognitive psychology and memory theories (Gagne, 1985; Hilgard & Atkinson 1992)	1) One or more basic theories in psychology must be assumed.
The set of activities that change the learners' mental schemas and in other words their cognitive constructs are considered as learning activities in this model. Change in the cognitive constructs of the procedural knowledge of pattern recognition through generalization and discrimination, change in the cognitive constructs of the procedural knowledge of action – sequence through the method of proceduralization, composition and automatization (Gagne, 1985) Change in the cognitive constructs of the procedural knowledge of heuristic procedures by teaching principles in simple situations to complex situations, Until the whole heuristic procedures is taught (Leshin et al., 1992:111)	2) A learning strategy should be defined to explain how learning and change in cognitive constructs.
Visible teaching structures should stimulate five basic patterns (Learning strategies, Development of routines and skills, Learning through motility, Knowledge building, Concept building)) that are used in teaching procedural knowledge (Oser & Baeriswyl, 2001).	3) Provide examples of observable teaching events.
Order the teaching steps of the teaching model of procedural knowledge of pattern recognition have a separate process from the procedural knowledge of action – sequence and procedural knowledge of heuristic procedures. The reason for this is the different nature of the types of procedural knowledge (Gagne, 1985).	4) The order and steps of the apparent operations of the teaching model must be present.

3.4. Basic patterns of teaching of procedural knowledge based on Oser and Baeriswyl perspective

In the 1960s and 1970s, the steady steps of teaching were considered destructive and innovative teaching was proposed instead. From this point on that educators and designers of teaching and learning patterns paid attention to the process of perception, memory, cognition, conceptual knowledge and meaning construction. In this regard, Oser and Baeriswyl (2001) paid attention to the importance of cognitive processes and their role in learning and teaching. They provided twelve basic patterns, each of which could be the basis for designing a suitable teaching model for specific areas. In their view, all learners in the learning process have the same basic patterns because these patterns contain a set of rules of learning psychology and are generalizable. Basic patterns are hypotheses about students' learning processes that are stimulated and encouraged by visible structures (a set of teacher actions and practices). Moradi (2010), according to the nature of procedural knowledge topics, used five of the twelve basic types of patterns identified by Oser and Baeriswyl to peresent a teaching model of procedural knowledge which is described in Table (2).

Table 2
The basic procedural knowledge patterns based on the twelve basic patterns of of Oser & Baeriswyl. (Moradi, 2010)

Basic procedural knowledge pattern	The main elements of the template
Learning strategies	1) encounter 2) perception 3) application 4) evaluation and generalization
Development of routines and skills	1) A: Practice a chain of action, B: A chain of content, C: Apply a set of rules. 2) Create an internal representation of that operational or content chain or rules through: breaking down the whole routine into small components, the anticipated limitations of each component of the routine, understanding the rules of communication between each component, defining each component. 3) Implement components A, B, or C through controlled feedback. 4) Evaluate the repeated execution of a, b and c until they are automated.
Learning through motility	1) Stimulation of sensitivity through pre-organizers. 2) Creating emotional tension through story, film, text, and speech. 3) Transfer of accumulated energy to a kind of creative expression (which can be in the form of paintings, pantomimes, music, stories, social performances, etc.). 4) Presenting and meditating on similar well-known works of art (a kind of indirect reinforcement of students' creative works.
Knowledge building	1) Direct or indirect stimulation of what the student initially knows about the meaning of the word. 2) Provide a new meaning along with an example. 3) Work on features that describe or compare the new word's meaning. 4) Active use of new meaning or word. 5) Active use of new meaning or word in other fields (analysis and combination of similar words and their meanings).
Concept building	1) Direct or indirect stimulation of what the student knows about the meaning of the new concept. 2) Present and work on a valid example of a new concept. 3) Analysis, classifications, and principles representing the new concept (positive and negative examples. 4) Active use of the new meaning or word. (Application, composition, and analysis). 5) Applying a new concept in new contexts (synergy of similar concepts in a complex knowledge system).

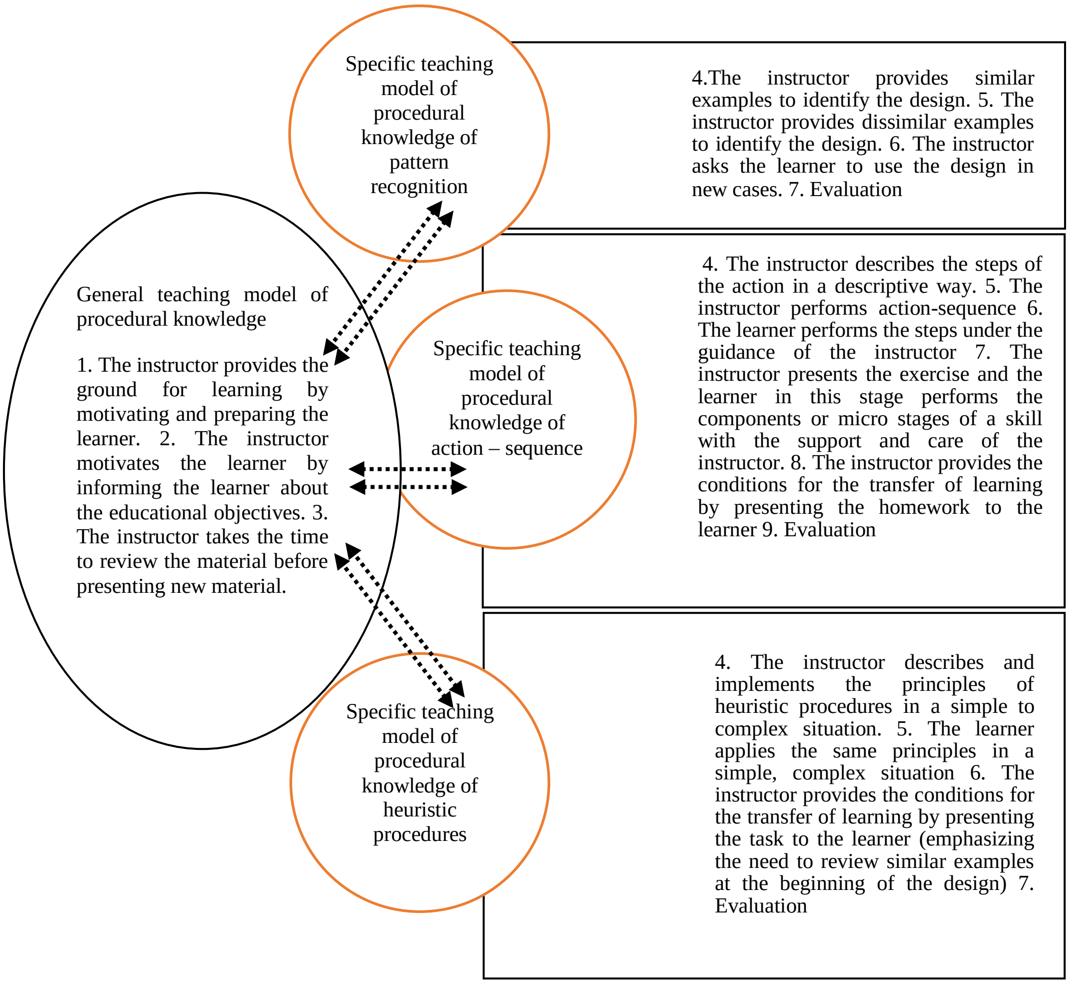

Fig. 2. A practical guide to applying the general and specific teaching model of procedural knowledge, Developed (by Authors)

3.5. Arrangement and functional aspects of teaching model of procedural knowledge

Moradi et al. (2011) based on the criteria for developing teaching models from the perspective Oser and Baeriswyl, inspired by the basic teaching patterns from their point of view and examining the characteristics of other teaching patterns, have presented the desired teaching model of procedural knowledge. One of the important features of this model is to explain and formulate psychological foundations, to show how to learn or to acquire procedural knowledge. This teaching model can be used to teach a variety of skills and processes that have a functional and procedural aspect (Moradi et al., 2011:113). According to the criteria for developing teaching models from Oser and Baeriswyl perspective, learning is a set of activities that change the learner's mental schemas and, in other words, their cognitive structures. Since the process of gaining the design ability is associated with changes in the learner's mental schemas and their cognitive structure, Therefore, the teaching model of procedural knowledge has features that can be significantly matched with teaching and learning procedures in architectural design studio. The development of visible structures of teaching from other dimensions is a proposed model. Visible structures express the functional aspects of teaching. According to the criteria that determine a teaching model, according to Oser and Baeriswyl (2001), the order of physical operations and functional aspects of the teaching model should be presented. In the teaching model of procedural knowledge, the first three stages are related to the general stages of teaching and the rest of the processes include specific stages of teaching different types of procedural knowledge. A practical guide to applying the general and specific model of teaching different types of procedural knowledge of "pattern recognition", "action–sequence" and "heuristic procedures" is presented in Figure (2).

4. Research Methodology

In terms of purpose, this research is applied research and its nature is a quantitative method. In this research, a quasi-experimental method with a control and experimental group design with pre-test, post-test and follow-up test has been used. first-year undergraduate students of architectural engineering in universities of Hamadan province, formed the statistical population of this study. Among them, 30 students of architectural basic design (I) lesson of Islamic Azad University, Hamadan Branch were selected as a sample by available sampling method. Of these, 15 in the control group and 15 in the experimental group were randomly assigned. The experiment was performed in the design studio of the architectural basic design (I) lesson in the first semester of the academic year 1399-1400. In this study, to collect the necessary information to test the research hypotheses, the following methods and tools were used. A) Library studies: Library studies including books, magazines, publications, dissertations, websites and other available resources were used to collect the information needed for the teaching model of procedural knowledge. B) Test: To collect the necessary information to test the hypotheses and achieve the goals, researcher-made tests (pre-test, post-test and follow-up test) were used. These tests were performed according to the schedule in both groups. Pre-test was performed by performing five tasks in both experimental and control groups. Tasks included: analyzing the volumes and geometric shapes used in a villa, presenting the plan and view of the villa to the student and drawing a section of it, building a model of the villa, designing the entrance and information of a residential complex and drawing its isometric perspective. After performing these five tasks in both control and test groups, the performance of the subjects was measured by evaluating the quality of design products by a panel of judges consisting of instructors of the design studio of the architectural basic design (I). Training for the control group was done with the usual educational method and for the experimental group using the teaching model of types of procedural knowledge. Therefore, it can be said that in the present study, the teaching model of procedural knowledge in performing design task in a research case has been tested in the course of architectural basic design (I). The case study information is presented in Table (3):

Table 3
Case study information

Statistical sample			Execution time	Name of Course	Statistical population
Training in the usual way	Control group (6 girls, 9 boys)	30 students of architectural basic design (I) lesson of Islamic Azad University, Hamadan Branch were selected as a sample by available sampling method. Of these, 15 in the control group and 15 in the experimental group were randomly assigned	The first semester of the academic year 1399-1400	Architectural basic design (I)	first-year undergraduate students of architectural engineering in universities of Hamadan province
Training using the teaching model of procedural knowledge	Experimental group (4 girls , 11 boys)				

The educational content was prepared with the opinion of the subject experts according to the curriculum objectives of the course of architectural basic design (I). The content was then tailored to Merrill's educational objectives. From Merrill's point of view, the content of all training includes four elements of facts, concepts, procedures and principles (Fardanesh, 2005: 126). The relationship between the classification of Merrill's educational objectives and the types of procedural knowledge is presented in Figure (3). Then, the teaching model of different types of procedural knowledge corresponding to the type of content was used. (A practical guide to applying the teaching model of procedural knowledge according to Figure 2 is presented in the section on theoretical foundations of research). The post-test was through the final task, which was designed by the researcher according to the educational content and was validated by experts.

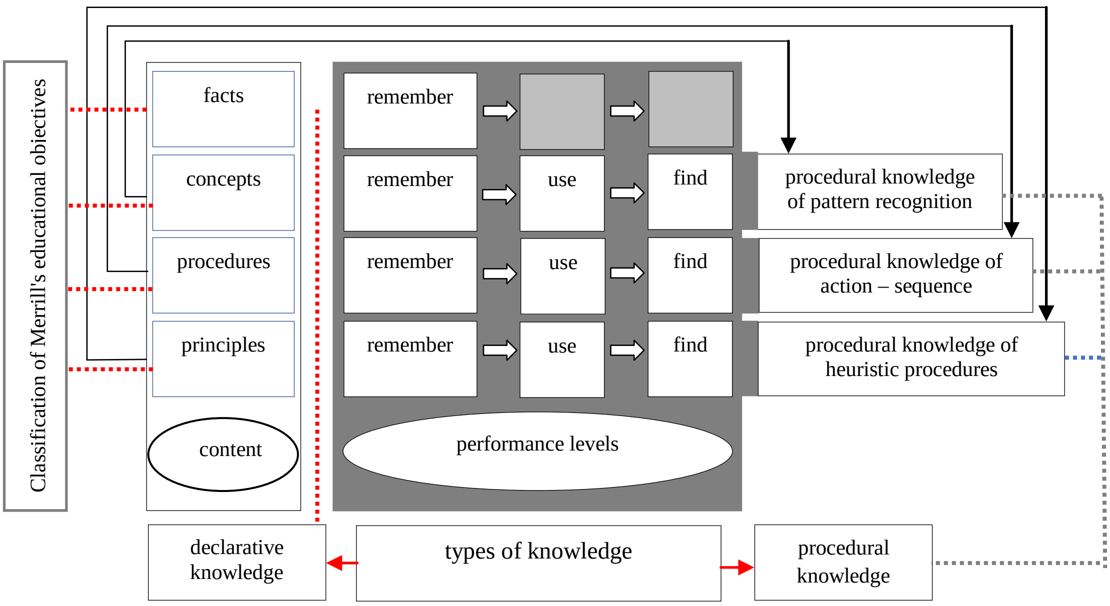

Fig. 3. Relationship between the classification of Merrill's educational objectives and the types of procedural knowledge, Developed

A seminar was held to introduce the final task and how to do it for both control and test groups, and the final task was presented in the second session as described in Table (4). Students had the opportunity to the semester.complete the final assignment by the end of the fifteenth session, commensurate with the topics taught during

Table 4
Description of the final task and its assessments indicators according to the type of procedural knowledge

Row	The final task	Type of procedural knowledge	Performance indicators
1	Analysis of geometric shapes and volumes used in the construction of the tomb of Bu Ali Sina	pattern recognition	identify the types of volumes used in the building and the methods of combining it
		action – sequence	Drawing quality (accuracy, precision, cleanliness)
2	Presenting the plan and view of Bu Ali Sina's tomb to the student and drawing the desired section of it	pattern recognition	Observance of drawing principles and rules
		action–sequence	Drawing quality (accuracy, precision, cleanliness)
3	Construction of a simplified maquette of the tomb of Bu Ali Sina	pattern recognition	Observance of the principles of making a maquette
		action–sequence	maquette fabrication quality (accuracy, precision, cleanliness)
4	Designing a volume and plan with information and guarding function at the beginning of the entrance of the tomb and in the specified location and making a maquette of it (micro-spaces including: ticket sales room: 10 square meters, rest room: 12 square meters, bathroom: 2.5 square meters, pantry: 4 Square meters)	pattern recognition	Observance of the principles of volume composition, observance of the principles and rules of drawing, observance of the principles of making a maquette, Observance of design principles (plan)
		action–sequence	Drawing quality (accuracy, precision, cleanliness) maquette fabrication quality (accuracy, precision, cleanliness)
		heuristic procedures	design ideas
5	Three-dimensional axonometric image drawing 30-60 volumes designed	pattern recognition	Observance of drawing principles and rules
		action – sequence	Drawing quality (accuracy, precision, cleanliness)

Post-test was performed in both experimental and control groups by using the final task in the design studio of architectural basic design (I). Data were collected by measuring the performance of students in homework by the jury. The jury was selected from among the faculty members of the Department of Architecture of the Islamic Azad University, Hamadan Branch, who had a history of teaching basic education courses, including the architectural basic design (I). In performance assessments or performance tests, students' learning processes and products are directly assessed (Seif, 2005). For this reason, the research data is the result of measuring the quality of the design product of the students of the experimental and control groups. Measuring the quality of products requires the determination of valid criteria and indicators. After determining the assignments in terms of the type of procedural knowledge, criteria and indicators for measuring student performance were determined through study and consultation with experienced instructors and design experts. The mentioned indicators are:

Table 5
Indicators for measuring student performance in evaluating the teaching model of types of procedural knowledge

Evaluating the teaching model of types of procedural knowledge	Indicators for measuring student performance
Evaluating the teaching model of procedural knowledge of pattern recognition	observing the principles and rules of drawing (observing the thickness of lines, scale, inserting correct symbols, drawing lines not seen), identifying types of volumes and methods of combining them (recognizing geometric and non-geometric volumes, recognizing various methods of combining volumes: connecting volumes, reducing Volumes, combination of both methods), observing the principles of volume composition (observing balance and proportion), observing the principles of model making (observing scale, proportions, correct choice of materials) observing the principles of plan design (observing the minimum dimensions of space according to rules and standards, recognition Optimal spatial relations). Measuring the performance of architectural freshman student according to these indicators indicates the student's ability to recognize

	concepts and principles.
Evaluating the teaching model of procedural knowledge of action–sequence	drawing quality (accuracy, precision, cleanliness), maquette construction quality: (accuracy, precision and cleanliness). According to the evaluation of the mentioned indicators, the student's ability to perform consecutive functions is examined.
Evaluating the teaching model of procedural knowledge of heuristic procedures	the quality of the design idea (innovation in answering the problem and creating new answers). By measuring the quality of the design idea, the student's ability to solve the problem is evaluated.

In this study, the types of teaching models of procedural knowledge as an independent variable and indicators for measuring student performance, which have been determined separately to evaluate the types of teaching models of procedural knowledge, were examined as a dependent variable as described in Table 6.

Table 6
Independent and dependent variables in research hypotheses

Hypothesis	independent variable	dependent variable	
Hypothesis 1: The teaching pattern of procedural knowledge of pattern recognition affects improving the design ability of architectural freshman student.	pattern recognition	Student performance (ability to recognize conceptsand principles)	Observance of drawing principles and rules
			Identify the types of volume and its composition methods
			Observing the principles of volume composition
			Observance of the principles of making a maquette
			Observe the principles of plan design
Hypothesis 2: The Teaching pattern of procedural knowledge of action – sequence affects improving the design ability of architectural freshman student.	action–sequence	Student performance (ability to perform consecutive actions)	Drawing quality
			Quality of maquette construction
Hypothesis 3: The teaching pattern of procedural knowledge of heuristic procedures has an effect on improving the design ability of architectural freshman student.	heuristic procedures	Student performance (problem-solving ability)	Quality design ideas

Table 7
Table of Descriptive indicators of the two groups in pre-test, post-test and follow-up test

Variable	Level	Group	N	Average	The standard deviation	Average standard error
Ability to recognize principles and concepts	pre-test	experiment	15	1.440	1.866	0.482
		Control	15	1.720	2.156	0.557
	post-test	experiment	15	17.587	0.817	0.211
		Control	15	16.313	1.027	0.265
	follow-up test	experiment	15	17.227	0.810	0.209
		Control	15	15.367	1.070	0.276
Ability to do Consecutive functions	pre-test	experiment	15	1.267	3.348	0.864
		Control	15	1.400	3.699	0.955
	post-test	experiment	15	17.750	0.881	0.228
		Control	15	16.300	1.099	0.284
	follow-up test	experiment	15	17.017	0.961	0.248
		Control	15	15.401	1.030	0.266
problem-solving ability	pre-test	experiment	15	1.200	3.189	0.823
		Control	15	1.333	3.539	0.914
	post-test	experiment	15	17.633	0.855	0.221
		Control	15	15.867	1.008	0.260
	follow-up test	experiment	15	18.567	0.821	0.212
		Control	15	16.467	1.125	0.291

Determining the statistical population: The statistical population included the first-year undergraduate students of architectural engineering in universities of Hamadan province. Among them, 30 students of architectural basic design (I) lesson of Islamic Azad University, Hamadan Branch were selected as a sample by available sampling method. Of these, 15 people in the control group and 15 people in the experimental group were randomly assigned.

Test design: Researcher-made test (design task approved by experts) to perform pre-test, post-test and follow-up test

Pre-test run: Perform pre-test and measure the performance of the subjects (control and experimental group) in the design task by the jury according to the pre-determined criteria and indicators

Training in the usual way: Training for the control group using the usual educational method

Training using the teaching model of procedural knowledge: Training for the experimental group using the teaching model of procedural knowledge (Determining the objectives of architectural basic design (I) lesson according to the curriculum, Prepare training content based on objectives, Organize content into four elements: facts, concepts, procedures, and principles based on classification of Merrill's educational objectives, Identify and classify content elements based on the types of procedural knowledge, Applying the teaching model of different types of procedural knowledge in accordance with the type of procedural knowledge.

Post-test run: Performing post-test and measuring the performance of the subjects (control and experimental group) in the design task by the jury according to the pre-determined criteria and indicators

Follow-up test run: Performing a follow-up test three weeks after the end of the sessions and measuring the performance of the subjects (control and experimental group) in the design task by the jury according to the pre-determined criteria and indicators.

Data analysis: Comparison of the design ability of control and experimental group based on the data obtained from measuring their performance with using descriptive statistics (mean, variance, median, standard deviation, etc.), inferential tests (covariance and its defaults) and t-test

Fig. 4. The steps of research implementation

Three weeks after the end of the sessions, the follow-up test was performed by performing five tasks in both the test and control groups. The tasks were: presenting the plan, view and perspective of a volumetric composition to draw a section and analyze the volumes and geometric shapes used in it, making a maquette of the mentioned volumetric composition, designing a prayer hall and drawing its isometric perspective. After performing these five tasks in both control and test groups, the performance of the subjects was measured by evaluating the quality of design products by a panel of judges consisting of instructors of the architectural basic design (I). After evaluating the students' performance by the jury, the evaluation results of these assignments were matched with the evaluation results of pre-test and post-test assignments and the result was reported. Inferential statistics (analysis of covariance) was used to analyze the data. The steps of research implementation are summarized in Figure (4).

5. Findings

Descriptive indicators (mean and standard deviation) of pre-test, post-test and follow-up test scores by group (control and test) are given in Table 7.
According to the results obtained in Table 7, the means obtained in the post-tests of all three educational groups (ability to recognize principles and concepts; ability to perform consecutive actions; ability to solve problems) are higher than the average Pre-test, also the experimental group in the post-test all three variables have a higher mean.
The results of the follow-up test also show the persistence of the effects of the teaching model of different types of procedural knowledge. The main purpose of this study was to investigate the effect of teaching model of procedural knowledge on improving the design ability of architectural freshman students with the following hypotheses:
1) The teaching model of procedural knowledge of "pattern recognition" affects improving the design ability of architectural freshman students 2) The teaching model of procedural knowledge of "action–sequence" affects improving the design ability of architectural freshman students. 3) The teaching model of procedural knowledge of " heuristic procedures " affects improving the design ability of architectural freshman students. Each of these hypotheses is statistically analyzed according to the collected data. Univariate analysis of covariance was used to test the research hypotheses. Analysis of covariance is commonly used in pre-test and post-test designs. This test has prerequisites, which need to be checked before doing it, and these prerequisites must be met to perform the analysis of covariance. Although there are several prerequisites for this test, here are three of the most important ones (including data normality, variance

homogeneity, and regression slope homogeneity) for each The two groups are referred to separately in three variables (ability to recognize principles and concepts; ability to perform sequential actions; ability to solve a problem).

A) Normality of data (Kolmogorov-Smirnov)

There are prerequisites for using parametric tests, which are: data normality conditions and data randomness conditions . The first condition should apply to all data, but the second condition applies only to historical data (data obtained over time-such as temporal regression analyses). To evaluate the normality of the factors, the Kolmogorov-Smirnov single-sample test was used as follows in accordance with Table 8.

Ho: The data have a normal distribution

H1: The data are not normally distributed

Table 8

Kolmogorov-Smirnov test to determine the normality of research variables

Statistical parameters		Ability to recognize principles and concepts	Ability to do Consecutive functions	problem-solving ability
N		30	30	30
Normal parameters	Average	16.95	17.02	16.75
	Standard deviation	1.98	3.46	3.31
Z		2.425	2.823	2.831
The significance level		0.231	0.502	0.564

According to Table 8, it can be concluded that because the values of the significance level of research variables in both groups and in the three variables (ability to recognize principles and concepts; ability to perform sequential operations; ability to solve problems) are more than ($p \leq 0.05$) So it can be said that the obtained data are normal and the null hypothesis of the research is confirmed. Therefore, parametric tests (analysis of covariance) can be used to analyze research hypotheses.

B) Homogeneity of variances (Leven test)

One of the important assumptions in analysis of variance-covariance is the homogeneity of group variance. Leven test is used to check the homogeneity and homogeneity of variances, the results of which are reported in Table 9.

Table 9

Leven test to check the homogeneity of variances

Group	Level	Leven test	Degrees of freedom		The significance level
			First	Second	
Ability to recognize principles and concepts	pre-test	0.125	1	28	0.726
	post-test	1.812	1	28	0.189
Ability to do Consecutive functions	pre-test	0.60	1	28	0.809
	post-test	1.315	1	28	0.261
problem-solving ability	pre-test	0.65	1	28	0.801
	post-test	0.109	1	28	0.744

The results of Table 9 showed that at a significant level ($p \leq 0.05$) the variance of Haas of all three variables (ability to recognize principles and concepts; ability to perform sequential operations; ability to solve problems) in the pretest and post-test is consistent and above the mean level The desired values are (0.05), so the analysis of covariance can be used to examine the differences between groups.

C) Regression slope homogeneity test

In this assumption, it is necessary that the slopes of the regression lines for the covariates (in relation to the dependent variable) be the same between the groups (experimental and control), which can be determined by an F test on the interaction of the independent variables with Evaluate the covariates (control variable). If the F test was significant, it means that this default has been violated (according to Table 10).

Table 10

Regression slope homogeneity test

Groups	Index	Total squares	Degrees of freedom	Average squares	F	The significance level
Ability to recognize principles and concepts	Group	0.8143	2	5.407	0.7391	0.287
	pre-test	5242.4	1	5242.484	5.5648	0.000
	Group confrontation/ pre-test	0.8143	2	5.407	0.7391	0.287
	error	25.441	27	.942		
Ability to	Group	3.502	2	1.751	1.181	0.322

do Consecutive functions	pre-test	7525.9	1	7525.949	5.075	0.000
	Group confrontation/ pre-test	3.502	2	1.751	1.181	0.322
	error	40.042	27	1.483		
problem-solving ability	Group	5.960	2	2.980	1.920	0.166
	pre-test	7288.2	1	7288.265	4.695	0.000
	Group confrontation/ pre-test	5.960	2	2.980	1.920	0.166
	error	5.96	27	1.552		

The results obtained in Table 10 to investigate the homogeneity of the regression slope showed that the values of F were calculated (F = 1.739), (F = 1.181) and (F = 1.920) by three groups (ability to recognize principles and concepts; ability to perform consecutive operations, The ability to solve the problem). for the confrontation of covariates (pre-test) with groups (experiment-control) is insignificant at the significant level ($p \leq 0.05$). In other words, a significance level above 0.5 indicates the homogeneity of the three-variable regression slope. Therefore, it can be said that the regression slope is homogeneous in all three variables (Figure 5) and the Correlation test can be used to analyze the data.

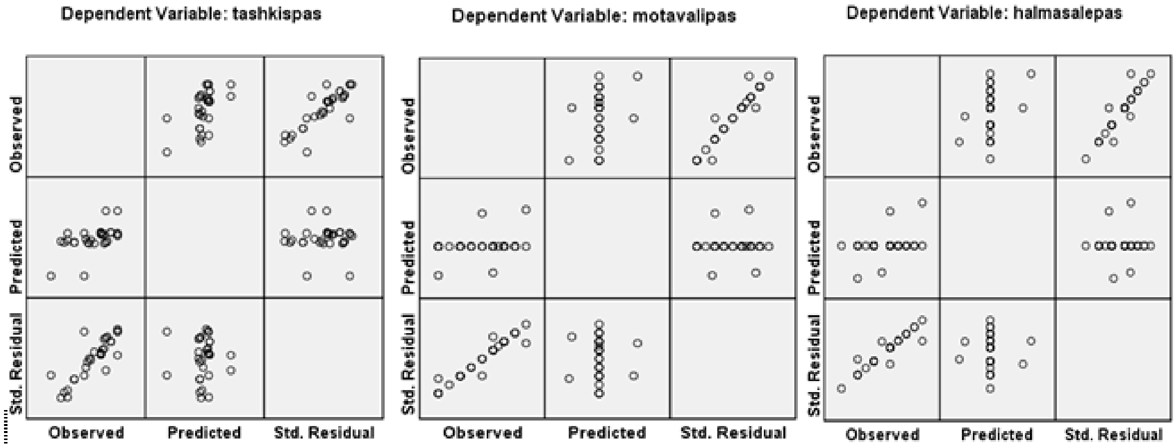

Fig. 5. Regression slope homogeneity diagrams in all three research variables

5.1 Analysis of research hypotheses

5.1.1 Hypothesis 1: The teaching model of procedural knowledge of " pattern recognition " affects improving the design ability of architectural freshman students.

Table 11
Covariance variance matrix

F	1.387
Degrees of freedom (1)	1
Degrees of freedom (2)	28
Degrees of freedom (2)	0.249

Table 11 shows the multivariate test of variance covariance matrix. The F obtained at the significant level ($p \leq 0.05$) is not significant. In other words, the significance of F indicates the existence of homogeneity of the variance matrix of covariance. Then, for the significance of the difference between the means obtained, the analysis of covariance of the groups (The teaching model of procedural knowledge of "pattern recognition" on improving the design ability of architectural freshman students) has been used.

Table 12
Covariance analysis test to compare the mean of the two control and experimental groups in the post-test

Groups	Total squares	Degrees of freedom	Average squares	F	The significance level	Eta coefficient
pre-test	0.331	1	0.331	0.376	0.545	0.014
Groups	11.813	1	11.813	13.425	0.001	0.332
error	23.764	27	0.880			

The results of analysis of covariance in Table 12 show that there is a significant difference between the mean post-test scores of the two groups in the design ability of architectural freshman students by controlling the effect of the pretest (F = 13.42). Thus, according to the results of the analysis of covariance test, it can be said that the teaching model of procedural knowledge of pattern recognition affects improving the design ability of architectural freshman students. The obtained effect index (ETA coefficient) indicates that 33% of the increase in the design ability of students in the experimental group is due to the effect of teaching model of procedural knowledge of pattern recognition.

5.1.2 Hypothesis 2: The teaching model of procedural knowledge of "action–sequence" affects improving the design ability of architectural freshman students.

Table 13
Covariance variance matrix

1.315	F
1	Degrees of freedom (1)
28	Degrees of freedom (2)
0.261	Degrees of freedom (2)

To test this research hypothesis, multivariate analysis of covariance was used. Table 13 shows the multivariate test of variance covariance matrix. The F obtained at the significant level ($p \leq 0.05$) is not significant. In other words, the significance of F indicates the existence of homogeneity of the variance matrix of covariance. Then, for the significance of the difference between the means obtained, the analysis of covariance of the comparison of the groups (teaching model of procedural knowledge of action–sequence on improving the design ability of architectural freshman students) has been used

Table 14
Covariance analysis test to compare the mean of the two control and experimental groups in the post-test

Groups	Total squares	Degrees of freedom	Average squares	F	The significance level	Eta coefficient
pre-test	0.034	1	0.034	0.033	0.857	0.001
Groups	15.791	1	15.791	15.370	0.000	0.363
error	27.743	27	1.028			

The results of analysis of covariance in Table 14 show that there is a significant difference between the mean post-test scores of the two groups in the design ability of architectural freshman students by controlling the effect of the pretest (F = 15.37). Thus, according to the results of the analysis of covariance, it can be said that the The teaching model of procedural knowledge of "action–sequence " affects improving the design ability of architectural freshman students. The obtained effect index (ETA coefficient) indicates that 36% of the increase in the design ability of students in the experimental group is due to the effect of the teaching model of procedural knowledge of "action–sequence".

5.1.3 Hypothesis 3: The teaching model of procedural knowledge of "heuristic procedures" affects improving the design ability of architectural freshman students.

Table 15
Covariance variance matrix

0.151	F
1	Degrees of freedom (1)
28	Degrees of freedom (2)
0.700	Degrees of freedom (2)

Table 15 shows the multivariate test of variance covariance matrix. The F obtained at the significant level ($p \leq 0.05$) is not significant. In other words, the significance of F indicates the existence of homogeneity of the variance matrix of covariance. Then, for the significance of the difference between the means obtained, the analysis of covariance of the groups (The teaching model of procedural knowledge of "heuristic procedures" on improving the design ability of architectural freshman students) has been used.

Table 16
Covariance analysis test to compare the mean of the two control and experimental groups in the post-test

Groups	Total squares	Degrees of freedom	Average squares	F	The significance level	Eta coefficient
pre-test	0.072	1	0.072	0.079	0.781	0.003
Groups	23.452	1	23.452	23.952	0.000	0.490
error	24.395	27	0.904			

The results of analysis of covariance in Table 16 shows that there is a significant difference between the mean post-test scores of the two groups in the design ability of architectural freshman students, by controlling the effect of the pre-test (F = 23.95). Thus, according to the results of the analysis of covariance, it can be said that the teaching model of procedural knowledge of " heuristic procedures " affects improving the design ability of students. The obtained effect index (ETA coefficient) indicates that 49% of the increase in the design ability of architectural freshman students in the experimental group is due to the effect of the teaching model of procedural knowledge of "heuristic procedures".

5.2 Average scores of follow-up test of experimental and control students

A) The ability to recognize principles and concepts

T-test was used for two independent groups to evaluate the difference between the scores of the students in the experimental group and the control group. Table 16 shows the results of descriptive statistics including number, mean and standard deviation. According to the average results, the ability to recognize the principles and concepts of students in the experimental group (17.22) in the teaching model of procedural knowledge of "pattern recognition" is more than the control group (15.36).

Table 17
Descriptive statistics of research variables

Average standard error	The standard deviation	Average	N	Group
0.2091	0.810	17.226	15	experiment
0.2763	1.070	15.366	15	Control

Part two contains the results of the t-test. According to the value of t (t = 5.365) observed in the table and based on the level of significance ($p \leq 0.05$), it is clear that there is a significant difference between the two groups (experimental and control) in the persistence of the ability to recognize principles and concepts. Considering the difference between the means, it can be said that the persistence of the ability to recognize the principles and concepts in the students of the experimental group is higher than the students of the control group.

Table 18
T-test to check the difference between the means

	T-test to compare means						
	t	Degrees of freedom	Sig.	difference in averages	standard error)	95% Differences in levels	
						The least	The most
Assumption of equality of variance	5.365	28	0.000	1.860	0.3465	1.150	2.569

B) Ability to perform sequential operations

T-test was used for two independent groups to evaluate the difference between the scores of the students in the experimental group and the control group. Table (19) shows the results of descriptive statistics including number, mean and standard deviation. According to the results, the average ability of the experimental group to perform consecutive actions of students (18.56) in the teaching model of procedural knowledge of "action – sequence" is more than the control group (16.46).

Table 19
Descriptive statistics of research variables

Average standard error	The standard deviation	Average	N	Group
0.2483	0.961	17.016	15	experiment
0.2651	1.029	15.400	15	Control

Part two contains the results of the t-test. According to the value of t (t = 5.839) observed in the table and based on the level of significance ($p \leq 0.05$), it is clear that there is a significant difference between the two groups (experimental and control) in the persistence of consecutive operations. Considering the difference between the means, it can be said that the persistence of the ability to perform consecutive functions in the students of the experimental group is higher than the students of the control group.

Table 20
T-test to check the difference between the means

T-test to compare means							
95% Differences in levels		standard error	difference in averages	Sig.	Degrees of freedom	t	
The most	The least						
2.361	0.871	0.3635	1.616	0.000	28	4.443	Assumption of equality of variance

C) The ability to solve a problem

T-test was used for two independent groups to evaluate the difference between the scores of the students in the experimental group and the control group. Table 21 shows the results of descriptive statistics including number, mean and standard deviation. According to the results, the average ability of problem-solving of students of in the experimental group (18.56) in the teaching model of procedural knowledge of " heuristic procedures " is more than the control group (16.46).

Table 21
Descriptive statistics of research variables

Average standard error	The standard deviation	Average	N	Group
0.2115	0.820	18.562	15	experiment
0.2902	1.105	16.462	15	Control

Part two contains the results of the t-test. According to the value of t (t = 5.839) observed in the table and based on the level of significance ($p \leq 0.05$), it is clear that there is a significant difference between the two groups (experimental and control) in the ability to solve the problem. Considering the difference between the means, it can be said that the problem-solving ability in the students of the experimental group is more than the students of the control group.

Table 22
T-test to check the difference between the means

T-test to compare means							
95% Differences in levels		standard error	difference in averages	Sig.	Degrees of freedom	t	
The most	The least						
2.862	1.363	0.3596	2.100	0.000	28	5.839	Assumption of equality of variance

6. Conclusion and Discussion

In this study, the effect of teaching model of the different types of procedural knowledge, including "pattern recognition", "action–sequence" and "heuristic procedures" on improving the design ability of architectural freshman students in the design studio of architectural basic design (I) was studied. The results of the analysis of research data showed that the average scores of students in the experimental group (based on the teaching model of procedural knowledge) is higher than the average scores of students in the control group (conventional teaching method) that this difference is statistically significant. The teaching model of procedural knowledge of "pattern recognition" has had a positive effect on the ability to recognize principles and concepts. This finding is completely consistent with the results of (Mehrdoust et al., 2019) and (Schön, 1992) researches on the effect of using design precedents on improving design ability. The teaching model of procedural knowledge of "action–sequence" has had a positive effect on the ability to perform sequential actions. This finding confirms the improvement of learner's cognitive skills through the application of the method of cognitive apprenticeship in research of (Talischi et al., 2012; Pressley & McCormick. 1995; Collins et al., 1991). The teaching model of procedural knowledge of " heuristic procedures " has had a positive effect on the problem-solving ability of architectural freshman students. In addition, this finding in line with research of Sadram, (2012) indicates an increase in the ability to solve problems through the learner imitating the design process of the instructor and repeating his behavior.

The teaching model used in this research is based on the study of procedural knowledge and the criteria that determine a teaching model in terms of "Oser" and "Baeriswyl". One of the defining criteria of the teaching model from "Oser" and "Baeriswyl" perspective is to identify learning strategies to explain how to learn and change cognitive structures. Considering that the set of activities that change the mental schemas of learners and in other words their cognitive constructs have been considered as learning activities in the teaching model of procedural knowledge, it seems that using this model teaching in the design studio of architectural basic design (I) makes students more cognitively involved with the subject. Changes in cognitive constructs of of procedural knowledge of "pattern recognition through generalization and discrimination, changes in cognitive constructs of procedural knowledge of " action – sequence through the method of proceduralization, composition and automatization, and changes in the cognitive constructs of "heuristic procedures" through teaching principles in simple to complex situations. It can be said that the increase in cognitive involvement in the teaching model of different types of procedural knowledge is one of the factors that has increased the design ability of architectural freshman students in the experimental group compared to the control group. Perhaps one of the reasons for the effectiveness of the teaching model of procedural knowledge is to motivate architectural freshman students, which has been introduced as one of the general stages of teaching different types of procedural knowledge. If the learner does not have enough motivation and preparation to learn at the beginning of learning, the teaching practice will not lead to learning (Fardanesh, 2005). The results of the analysis of research data in the follow-up test indicate that the average scores of the follow-up test of experimental group students (based on teaching model of procedural knowledge of pattern recognition and teaching model of procedural knowledge of action–sequence) from the mean scores of the control group follow-up test It is less and this difference is significant and indicates that the learning of the experimental group is more stable than the control group. It seems that the teaching model of procedural knowledge of pattern recognition and teaching model of procedural knowledge of action–sequence has led to deeper memory processing and has led to deep learning in learners. Architectural freshman students in the teaching model teaching model of procedural knowledge of pattern recognition and action–sequence, try more to use the strategy of recalling past learning, in other words, in this teaching model, it is possible for them to achieve meaningful learning and this causes Students in the experimental group have more retention than the control group who use the standard teaching model. On the other hand, the increase in the mean scores of the experimental group of students in the experimental group (based on the teaching model of procedural knowledge of heuristic procedures) is higher than the mean scores of the continuous test of the control group and this difference is significant and It indicates that the ability of the experimental group students to create innovative ideas to solve the problem has increased significantly. The most important factor in the effectiveness of the teaching model of procedural knowledge of heuristic procedures compared to the conventional teaching method is the emphasis on examining similar examples and design precdents as carriers of design knowledge, Which has led to the growth of design schemas and increased problem-solving ability of architectural freshman students. Understanding the nature of the content of education according to the type of knowledge that it discusses and choosing the appropriate teaching model can facilitate the development of design ability of architectural freshman students who are in the naïve stage in terms of design ability. The final result of this research shows that the teaching model of procedural knowledge including "pattern recognition", "action–sequence" and " heuristic procedures " is effective in improving the design ability of architectural freshman students.

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