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To develop a model for design protocol in the research-based design process in architecture education

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Abstract

Despite a great deal of effort has been made to present systematic models of design process, in practice, a lot of designs still proceed through unsystematic methods. It seems that the reason for this is too much emphasizing on describing the final design (product) and little attention to the design process; such that, there is no clear method so as to research-based design. This led to illustrate a distinct pattern from configuration of "design protocol" in terms of research-based design process. The aim of this study is to develop a model that can be used in the architecture educational system. So at first step, the readers of this research are architecture students, and designers can also benefit from it in the next steps. So that all the readers of this research using this model, in a logical process, can recognize the right information for design and ultimately achieve an optimal architectural design. In this research, our preferred context is architecture, and the focus is on research-oriented design; therefore, any given example would be in the field of architecture. In this paper, the proposed process is the result of experience gained from five years teaching architectural design (2) in master's degree that includes three milestones as follows: 1) Statement of problem 2) The scheme and 3) Design protocol. "Statement of design problem" is obtained from people's concerns about "design subject" integrated in its "bed". The scheme, itself, constitutes the expectations, goals and mission representing two sets of information (cognitive and distinction) about design that finally leads to establish a "spatial-body program" of the project. As proceeding from the onset of diagram into the end, we passed from "analyze" into "synthesize" phase. In fact, in «analyze» phase, designer decides to collect and analyze information; however, as the process goes forward, he/she combines the information from the previous phase in order to achieve novel findings. Finally, we hope that by taking advantage of the proposed process, designers can find the best way to accomplish their design projects within a defined framework.

Keywords: research-based design process, design protocol, design problem, scheme, spatial-physical program, architecture.

1. Introduction

The design process along with what designers see and think about (Liu & Group, 1996) is one of the most sophisticated human activities (Hybs & Gero, 1992). In architectural research studies, the design phase has been known as process to solve the problem of the study (Cardoso et al., 2016). This process is composed of factors which are utilized by designer consciously or unconsciously, to solving the problem of the design. Although, the design process is considered of great importance than the final product, the design process is always ignored with the attention being focused on the final product (Hybs & Gero, 1992). Nowadays, the design process is known as complex mental activity, and many independent factors and elements are influencing the architectural design, due

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to fast growth of technology and expands of needs; therefore, struggling to make a comprehensive perception of the design process is necessary.

A review of literature demonstrates that, the majority of research studies were conducted on the design process in late 1950s and early 1960s when, some conferences had hold on the design method. The first generation of the design methodology was launched in 1960s, when it was studied as an academic discipline for the first time. In the 1970s, a great deal of effort was carried out by people such as Christopher Alexander and Jones in this field. In the 1980s, several conferences were held and books were published such as "How designers think", by Brian Lawson. During the 1990s up to now, increasing efforts on the development of design studies have been done through holding conferences, scientific journals and books. In line with the previous studies, this study aims to develop a model for the formation of a "design protocol" that can be used in the architecture educational system, so that a systematic research-based method for designing an architecture is introduced in which students and architect designers, in a logical process, can summarize a perceptual and rational process in an acceptable model, while considering all the topics and concepts associated with the subject and ultimately, achieve an optimal architectural design. In general, a "research-based design" is a design performed at the basis of a specific concept. In fact, a research-based design is to give an identity to a concept in terms of architecture. Thus, this research assumes to design an architecture subject that has been figured based on a specific concept. Accordingly, the design process starts with determining the "design subject". Afterward, next design stages will be demonstrated step by step and the related diagram will be also displayed. Finally, subjects will be presented in terms of a final diagram of a "research-based design process".

2. Design Subject

Architectural design process often begins with determination of a "design subject". So, determining the design subject is the first step in architectural design process. Design subject is a representative aspect of a "design problem" as well as a transformer of design product features. In this study, a design subject, only includes design title, nominal aspect and its function. It is assumed that despite the designer has no imagination of the subject, he/she has to achieve sufficient knowledge of design subject. For this purpose, it is necessary for designer to initially deal with and analyze a design problem.

3. Design problem statement

In this section, the "problem statement" for design has been discussed. In general, the term problem statement is a concise and clear description of a subject that should be addressed in problem solving process. The characteristics of the problem statement comprise clarity and accuracy, identifying key concepts and terms, not using unnecessary terminology, expressing boundaries and parameters of the study, etc (Hernon & Schwartz, 2007). In fact, naming a subject does not mean to define that problem. This is also true in the architectural design process and a process can start with a design subject. It seems unlikely that all aspects of design problem have been clearly stated in the early stage of the process; so, the primary task of a designer is to identify the problem. Cross (1995) believes that one of the most important and effective steps in architectural design process is to analyze and understand the design problem (Cross & Cross, 1995). Architectural design problem is complex and ambiguous, so in order to reduce this complexity and ambiguity, designers need to configure the design problem. The reasons making design problem should be initially addressed to configure the design problem. The origin of design problem can be examined within its "context".

3.1. Context

Since there is no problem without a context and problems always have at least one context, in order to define the problem, its background as well as causes must be also well recognized (Cherry, 1999). Context is defined as external elements that affect an object. These elements are physical

and non-physical. Roads, buildings and visible land are examples of physical elements, while non-physical elements consist of weather, local culture, as well as political and economic restrictions (Firrdhaus & Sahabuddin, 2011). It could be argued that problems are inseparable components arising from their contexts. So, the nature of problems should be analyzed and recognized in their beds. On the other hand, framing the design problem is a cognitive process of overall objectives and problem characteristics (Pinch et al., 2010). Palmer, (1981) divides design subjects into three categories in order to organize raw design information to provide a framework: human factors, body factors and external factors (Palmer 1981, cited by Duerk, 1993). According to Lawson (2006), four groups comprising legislators, clients, users and designers impose constraints- albeit with different degrees of flexibility- on design solution (Lawson, 2006). In this paper, based on Palmer and Lawson categories, design problem constraints originate from two sources: a series of constraints arising from bed's sociocultural values and the other comes from human factors (people who are related to the architectural design).

3.2. Socio-cultural values

This section describes the relationship between culture and architectural design. So, first, it is necessary to define the word "culture". A lot of work has been done to define this word. However, it seems there are still many thinkers and experts facing many difficulties about concept, evidence and problems of the culture.

Tyler (1870) considers culture as "a complex set of knowledge, belief, art, ethics, customs, and any ability and habit that man acquires as a member of a society" (Tyler British anthropologist 1870: 1; cited by Avruch, 1998). The definition shows one of the factors that makes up the culture, beliefs and values of the society that is considered by the authors in this study. Hofstede et al (2010) also believe that culture makes a distinction between groups (Hofstede et al., 2010). It is understood from this definition that culture is the symbol and identity of a place that distinguishes it from other places and nations. Matsumoto & Juang (2016) and Dykstra (2009) consider culture as "a set of attitudes, values, beliefs, norms and behaviors shared by a group of people that is passed down from generation to generation which is effective on behavior of each member " (Matsumoto & Juang, 2016 & Dykstra, 2009). This definition also includes predefined and more complete definitions. Therefore, culture is a set of values and beliefs of a society that is the symbol and identity of a community that is transmitted from generation to generation. In his research, Firrdhaus & Sahabuddin (2011) describe culture as a way of living in a place and the best way to accept the constraints of a place that is followed by generation to generation. Culture sometimes becomes the symbol and identity of a place. Adaptive architecture is the most popular way of showing the identity of a place (Firrdhaus & Sahabuddin, 2011). In this study, we choose the definition of Firrdhaus & Sahabuddin as the basic definition, because it is close to our goal, i.e. the existence of a relationship between the architecture and the culture of a nation. Finally, our definition of culture is: "Culture includes beliefs, values, and faiths and in general the way of life shared in a place which is passed down from one generation another affecting the behavior of individuals. Culture is sometimes the symbol and identity of a place. Adaptive architecture is the most popular way of showing the identity of a place in this regard".

Therefore, it can be argued that architecture is one of the most obvious manifestations of the culture of any nation, and it shows the human living space. In fact, the same buildings and memorials of a nation are known as culture due to being rooted in beliefs and values, and in fact they are the connection between the culture and the architecture of a society. Architecture is a knowledge that establishes a close relationship with culture and originates as a social phenomenon from culture and affects it, while meeting the human need for shelter and built environment.

3.3. Human factors

Legislator: Legislator is the most inflexible factor which influences the design process (Lawson, 2006). Although the legislator is not often involved in design itself, he/she imposes some limits within the framework of which, designers should work (Lawson, 2006). Regulations set by

municipalities for any urban constructions are common examples of legislative influences on architecture.

Client: The second factor influencing the design process is the client of the project. Client is an obvious example of design limitation source (Lawson, 2006). According to Le Corbusier, architects must consider client design requirements and demands; they should establish a good mutual relationship while combining spaces and forms with artistic ideas (Parsaee et al., 2015). As Pena (2012) said, high quality buildings are not accidently constructed. These buildings are scheduled to perform well, and implemented when qualified architects and clients are joined together in thoughtful and collaborative efforts (Pena & Parshall, 2012). However, nowadays, many designs are ordered by the clients who themselves, do not use those designs. For example, public buildings such as hospitals and schools are usually designed by architects who have little relationship with users (Lawson, 2006). When clients themselves do not plan to use their designs in the future, the issue is even more ambiguous than it seems. The growing gap between designers and those the designs have been performed for, increases the need to study about user's demands (Lawson, 2006).

Users: The third group influencing the design process are design users. Users are experts in building usage (Pena & Parshall, 2012) and in fact the most important groups associated with the building. They work, present, play, inhabit, and live there. In most projects, there are many different types of users. Each of these groups has various views about the project. Understanding of all those views is very important to achieve a successful building (Cherry, 1999). On the other hand, successful construction projects have been designed, built and equipped to meet the users' needs. Either about the function of an entire building or designing a single space, users possess a unique knowledge which should be integrated in design to ensure a successful construction project (Christiansson et al., 2011). So, users should be pervasively involved in planning a process for building design.

3.4. Sociocultural

As mentioned, it is concluded that analysis of the design problem must be started from the context and bed. In this process, factors such as human factors (legislator, client, and user) as well as sociocultural values impose some restrictions on the design problem in which the common point between context and aforementioned factors is design subject. In fact, design subject connects these two sets of communicational factors. Thus, statement of design problem is obtained from merging worries, concerns and negative beliefs which originate from different views, including legislators, clients, users, operators and sociocultural values about design subject within its bed and expressing them through a unique term. In summary, an analytical diagram is provided as below (Figure 1):

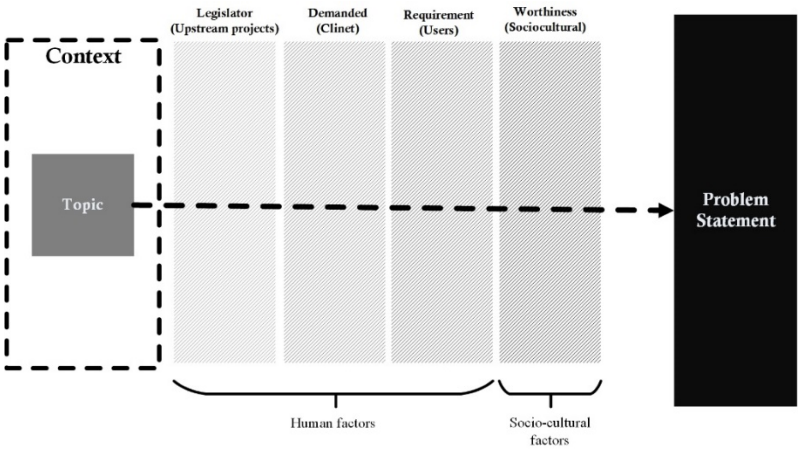

Figure 1 Formulation of design problem statement

In this paper, a practical example has been put at the end of each section for the sake of clarity. This selected example is a student project that was conducted by the third author of the article in the second plan of master's degree Program (during 2015 academic term at Hakim Sabzevari University) under the supervision of the first author. Here, example of problem statement to be shown (Table 1):

Table 1 Example of problem statement

topic		**Context**	
architectural faculty design		Site of Homa Hotel in Mashhad (bi-cornered site - area of 70,000 m^2) 	
Sub-phases	**specific explanation for project**	**Sub-problems**	**suggestion**
legislator	1. Height constraint up to floors 2. Using local materials 3.No increase in traffic load	1. Due to higher surrounding buildings, visual problems arise. 2. Surrounding buildings have not used local materials; a coordination problem with adjacent buildings exists. 3.1. Adjacent to two busy streets namely Ahmadabad and Kolahdouz 3.2 Design site is located at the intersection (causes congestion). 3.3. Adjacent to bus station from Kolahdouz Street	1. Design of different parts of a building at various heights (pilot parts are higher). 2. Designing friendly-environmental buildings (through utilizing renewable materials) 3. Define multiple entries for driveways (avoid making traffic at one point)
client	1. Research rehabilitation in architecture. 2. Designing faculty of architecture where the research is to be supported. 3. Designing faculty of architecture close to the professional community.	1. There is no value for research in existing architecture faculties, at all. 2. The priority is currently given to education instead of research. 3. A gap has happened between education and research. 4. Students have not been trained as researchers.	Research spaces should be provided in faculty; the appropriate strategies should be also adopted to attract students to research activities.
user	1. Research achieves a suitable place in the architecture course. 2. Providing spaces specially for research in faculty 3. Architectural design studio is designed such that in which, research activities will be carried out. 4. Providing spaces for conferences and meetings to convey information 5. Providing spaces for invited speakers 6. Providing a space where architecture connection is established with other areas of science and art.	1. There is no space assigned to research activities in the faculties of spatial architecture 2. The research is neglected in architectural design courses. 3. Design studio has been organized based on this view that design content should be directed toward practical purposes.	1. Designing faculty spaces considering research as a main priority 2. Designing studio space such that the students pass architectural design courses based on research. 3. Utilizing the site to provide outdoor spaces for meetings 4. Providing spaces especially for other scientific areas related to architecture
Cultural values	Designing architecture faculty so as to help develop and enhance the area	1. Low awareness of regional people 2. Lack of global updated knowledge 3. Failure to generate novel knowledge	Considering spaces which attract people; and increase their awareness, such as exhibiting spaces, outdoor lecture spaces to hold conferences with participation of community.
Problem Statement: "A gap between research and architecture": It seems that the major problem in project given is neglecting the research along with a gap between education and research educational system of architecture leading to weak students in field of research. When graduated students enter the professional labors, they more often design based on normative theories relying on individual perception; this leads to separation of academic and professional spaces in architecture.			

4. Scheme

In this section, "scheme" is explained which is considered as the third step in design process. In fact, the designer initially configures design problem to be able to understand it; then, he/she

presents scheme through it. Regarded to the word scheme, different meanings and definitions have been presented in various references. First, a number of these definitions are described.

According to Ruan (2010), scheme is a way through which human communications are organized with spatial arrangement (Ruan, 2010). Therefore, scheme can be considered as a regularizing factor. In part of the Webster Dictionary Definition (2017) of the scheme, the phrase "plan or action plan and a systematic or organized configuration (design)" has been given. In Oxford Dictionary (2017), "a large-scale systematic plan or arrangement to achieve a specific purpose" is the definition of scheme. According to the three definitions mentioned above, the scheme can be called the overall system of the structure.

On the other hand, Murphy (2002) sees the scheme as a model that integrates all our mental needs and helps us to identify and classify objects (Murphy, 2002). Therefore, the scheme should affect all the elements and components of the architectural design. Taura & Nagai (2013) call the scheme something that may be created by observing the properties of an object such as (appearance, attributes, functions, etc.) in the human mind or in the real world (Taura & Nagai, 2013). Therefore, it is argued that the scheme can be understood from the scale of the general design of the building to its more detailed parts. Darke (1979) interpreted the scheme as the "primary generator" (Darke, 1979). Therefore, it can be said that scheme can act as the initial spark of the scheme and follow up with subsequent ideas.

By summing up what mentioned above, we can call scheme the general system of structure that affects all elements and components of the architectural design and is understandable from the scale of the general design of the building to its most detailed parts. In fact, the scheme is the architectural response to the design issue; therefore, like a central core, it brings together all the components of the plan, including physical needs, environmental conditions, etc. followed by the following ideas. In his book, "Architectural Planning", Duerk (1993) also uses the term "purpose statement" that is intended to be close to our goal of scheme, that is; an appropriate purpose statement expresses the expected quality that the ideal solution or the final result must achieve. It also takes into account the wishes of the employer and the needs of the users. This statement of purpose should be short and focus on the quality of the environment that has set the "objectives" of the project. (Duerk, 1993). According to Duerk (1993), scheme consists of three sub-sections: goals, expectations, and missions.

4.1. Goals

"Goals", in fact, expresses the desires and intentions that a person tries to achieve. Goals are statements that will help us make design-related decisions. Among different types of goals affecting the project outcome, project goals are only related to the predicted results of project which are formed based on the client's requirements, user's needs and desired values (Duerk, 1993).

4.2. Expectations

This section is adapted from studies carried out by Gero (1992), Maher (1996, 1997) et al. Based on researches have been conducted by Hybs & Gero (1992), Maher & Poon (1996),Poon & Maher (1997), Maher & Tang (2003) and etc. we have found that according to the functional requirements and demands expressed in design problem space, the corresponding behavior of those requirements are taken into consideration which is called "expected behavior".Gero (2004) has also utilized the term "expected world" in a study with a representative model of the design process based on function - behavior - structure; the expected world is a world that will produce designer' supposed measures where the activities' effects are anticipated based on existing objectives and interpretations of the current state of the world (designer's problem space). In fact, when designers configure the design problem, some questions may reasonably arise that they have apparently a set of expectations about the answers to these questions (Dorst & Cross, 2001). Therefore, it can be recognized that a scheme must represent an accurate and appropriate expression of the

expected qualities within the project objectives to solve a design subject. In addition, the expectations are more abstract than goals which are more operational.

4.3. Mission

As defined by Duerk (1993), a mission is more related to the design subject. In a design project, "mission statement" is in fact a "major goal" which represents the main objective of the project dealing with the reason of implementing the project. For example, if it is decided to design a faculty of architecture, this question arises that what is the mission of an architecture faculty, and which characteristics and features must an architecture faculty have and what roles should it also plays. In general, mission, is a statement of the main objective of the project that must be successfully accomplished; it also includes a series of valued principles that assists to implement the project. This section is summarized in analytical diagram as below (Figure 2):

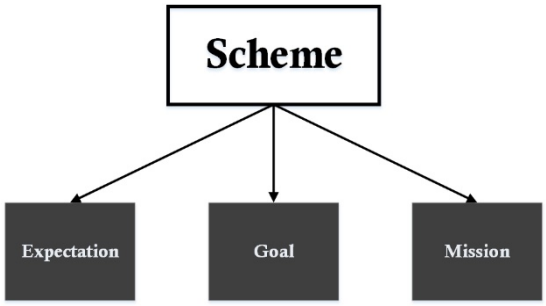

Figure 2 Formulation of "scheme"

Here, example of scheme to be shown (Table 2):

Table 2 Example of scheme

Scheme		
Sub-phases	**specific explanation for project**	
expectations	-	1. Extending the fields of research in architecture 2. Connectivity among citizens and faculty members increases citizens' awareness.
Goals	-	1. Rehabilitation of research in the faculty of architecture and making connections between the academic space and professional community in architecture: 1.1. Designing faculty spaces considering research as a main priority 1.2. Attracting architecture students to research activities 1.3. Establishing a connection between architecture and other scientific areas 1.4. Organizing architectural design studios based on research 1.5. Make Links between education and research (education coupled with research) in the faculty of architecture
Mission	-	architectural Faculty with its features and components
Scheme: Designing faculty of architecture in order to establish a link between research and architecture		

Generally, in research-based design, designer is concerned with two categories of information. First, the "general principles" or "cognitive studies" which are linked into the project mission. The other set of information entitled as "special principles" or "distinction studies" are related to the goals and expectations of the project.

5. Cognitive studies

In this section, cognitive studies of design project will be discussed. The term "cognitive" in the Webster Dictionary (2017) has been defined as conscious mental activity like thinking and reasoning, and activity based on actual experimental knowledge. Also, Oxford Dictionary (2017) has considered it as mental activity or the process of acquiring knowledge through thinking, experience and senses. In the Cambridge Dictionary (2017), it is an attribute associated with conscious thinking or mental processes and it is related to the process of knowing, understanding, and learning in the Longman Dictionary (2017). The raised meanings of the term cognitive generally overlap and are in line with each other. Therefore, it can be considered as a mental activity that is consciously carried

out and leads to knowing, understanding and learning something. According to this definition, the purpose of the writers of the "cognitive studies" is to carry out conscious activity that leads to the designer's knowledge of the subject of design. In fact, information and data are provided at the stage of cognitive studies according to the type of building uses and include a checklist of the names of the spaces and their dimensions. This checklist of spaces is provided, taking into account the criteria and standards as well as the specified per capita, which are reviewed below.

5.1. Regulations and standards

Design and development of the built environment are affected by the social-political and organizational (formal) complexities involving the application of rules and regulations related to the form and function of buildings; such that, since the first periods of architecture and construction, the architects' actions have been conditioned through a series of rules, regulations, standards, and monitoring practices including socio-cultural instructions, etc. (Imrie & Street, 2011) This control and monitoring is conducted in order to provide comfort, convenience, enjoy of the inhabitants, and also preserving the value of the properties. In fact, design's rules and standards have been considered as the most common method to control and monitor architecture. According to Imrie & Street (2011), the foundation of architectural rules and regulation is a part of a broad context of social- organizational and political intervention in design and development process which is used to determine the limits and definitions of the activities by architects. In general, regulations and standards in architectural design are considered as instructions set by the relevant governmental agencies such as the municipalities, housing and urban constructing department etc. These instructions are about the whole architectural generality of a building which affects architects' actions.

5.2. Per capita

"Per capita" refers to an index or measure calculated for each person of a community. In architectural design, spatial per capita is specifically calculated for that space's users.

5.3. Subspaces

Subspaces are places that exist in public parts of a building regarded to the usage issue. For example, if the design subject is a faculty of architecture, a list of the spaces which are common in the whole architectural faculties should be provided.

Based on the above, in cognitive studies step, considering regulations and standards, the designer provides a checklist of spaces' names, dimensions and qualitative characteristics regarded to spatial per capita. This checklist is actually a type of physical program for design subject called general program. 'Generality' is because that this list of spaces can be commonly used in all buildings with similar design subject. In brief, an analytical diagram is presented below (Figure 3):

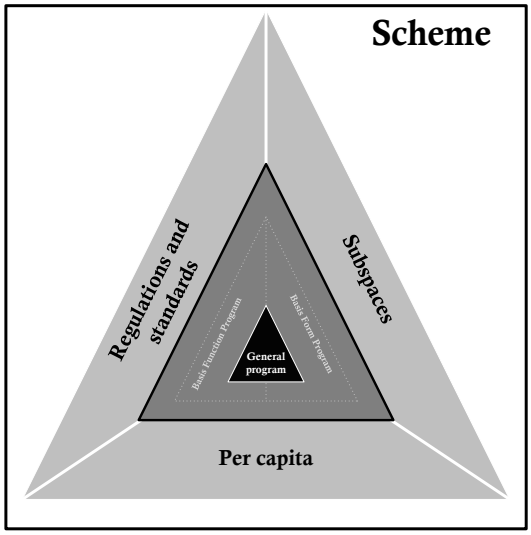

Figure 3 Cognitive studies (formulation of general program)

Here, example of general program to be shown (Table 3):

Table 3 Example of general program

Cognitive studies		
Sub-phases	**specific explanation for project**	
Regulations and standards	-	**General program:** A List of spaces within architecture faculty such as theoretical classes, practical classes, auditorium, administrative and service sectors as well as the number and dimension
Per capita	-	
Subspaces	-	

6. Distinction studies

In this section, "distinction studies" will be introduced. The term “distinction” in the Oxford Dictionary (2017) has been defined as the difference between the same acts, or individuals or groups, and the superiority that separates a person or something from others. Moreover, in Cambridge Dictionary (2017), this term means the difference between two similar things, and in the Longman Dictionary (v. 6, 2017), it is difference, superiority or exclusivity have been brought. These meanings generally overlap and confirm each other. Given the meanings, here the purpose of the writers of the term distinction is also the difference and distinction. The authors' purpose of distinction studies is a certain response to the design problem. It could be argued that each design is distinguished from another due to distinction studies. Because of having qualitative nature, design problems may include multiple responses; so, considering his/her creativity, design knowledge and experience, any designer differently responses to the design problem and adopts a specific "approach". Therefore, in the following, these three designer's abilities (creativity, knowledge and experience) will be discussed.

6.1. Creativity

Takala (1993) believes that creativity is perceived as the ability of a person to produce new and unexpected things (Takala, 1993). Csikszentmihalyi (1996) considers creativity as something resulting from the interaction of a system consisting of three elements, one of which is the person who brings something new (Csikszentmihalyi, 1996). In his definition of creativity, Ogot & Okudan (2007) uses the phrase "the ability to find new methods using existing knowledge for the production of new products" (Ogot & Okudan, 2007). Therefore, creativity can be defined as the ability to find new methods using existing knowledge in order to produce new things or solutions. Akin (1994) also considered creativity as developing new descriptions of the design problem in order to provide new solutions (Akin, 1994). Casakin (2008) considers the creative process to be able to define a problem from unusual view points and to seek out new solutions that are different from existing ones(H. Casakin, 2008). In these two definitions, as in the previous ones, we refer to the "production of new solutions", but from a different aspect, which is "a different look at the design issue". In this regard, (Kowaltowski et al., (2010) also defines creativity as a process of sensitization to a question in the field of knowledge. Therefore, it seems that a prerequisite for creativity is to look at design issue with a different perspective. On the other hand, Bergström (2000) also considers creativity as a natural activity of the brain and the human body, as well as a basic quality of each human being (Bergström cited by Haapasalo, 2000). Therefore, according to this definition, the power of creativity exists in all human beings and human beings can activate and take advantage of it in different ways.

Ultimately, the definition that writers consider based on what has mentioned above is: Creativity means the ability to find new ways to produce things or new solutions. The power of creativity lies in the existence of every human being from the beginning of birth and one of the ways to activate it in the design of architecture is to have a different perspective on design issues. On the other hand, it is always stated that designing is a creative profession and designers are creative people (Christiaans, 1992). So, it can be concluded that creativity is a key element in solving a design problem. Creativity is able to promote talented designer beyond his/her conventional knowledge in order to evaluate new ideas and concepts which may lead to innovative solutions (H. P. Casakin, 2007). On the other hand, because designing is one of the most complex activities of human brain

(Gero & Mc Neill, 1998; Liu & Group, 1996), the multiplicity of factors affecting design, makes it very difficult to discipline and unify activities. Therefore, exploring unfamiliar and unconventional design solutions along with creative skills also requires qualitative knowledge and experience.

6.2. Design knowledge

According to Goel (1995), design knowledge configuration is considered as a cyclic process comprising processing, recovery, research, classification, thinking and mental evolution of design information from long-term external memory to be utilized to frame design problem (Goel 1995, cited by Alhusban, 2012). In fact, creative people rely on their specific content knowledge to ratiocinate on the situations of essential issues and thus generate innovative solutions. This knowledge and expertise help designers make enriched and complex mental models to frame the design problem (Zeng et al., 2011). In general, design knowledge, further defines the information (Blosiu, 1999) which is used to communicate main ideas in each part of design process.

In architectural design training, knowledge is also an important factor to develop innovative thinking skills learned as a significant component (Oxman, 2004). Architectural design is a creative knowledge-based activity (Al-Sayed et al., 2010) and designer utilizes that to modulate design goals, define design subjects, and develop design solutions. Design knowledge plays an important role in reducing the probability of design error and enhancing the quality of design (Chiu, 2010). In other words, the design knowledge can be defined in two ways: a set of information designer acquires through different methods such as university studies and stores them in his/her long-term memory to be utilized when necessary. Second, a set of information designer gains on a particular subject through different ways such as interviewing with people.

6.3. Experience

In general, experience and knowledge in a particular field have been accounted as general preconditions for expertise development (H. Casakin & Goldschmidt, 1999). Architecture is not an exception. The importance of designer's experience in architectural process design has been ever confirmed by many scholars. They consider generation of ideas and concepts of architecture related to design knowledge, inspiration, intuition, imagination, analytical skills of analysis/combination, cognitive skills, training, creative thinking abilities as well as experience (Alhusban, 2012). They also believe that design is based on acquiring skills, exercise and experience (Goldschmidt & Weil, 1998) and designer's thinking about the design process is based on personal experiences (Kokotovich & Purcell, 2000). Designer's experience in architecture can affect his/her design's inherent approaches and characteristics. Furthermore, cultural background and life experience of designer can also play an important role to structure his/her ideas during the design process. It should be noted that the architectural knowledge is required to be broadly and interdisciplinary expanded for a unique design solution in order to cover all subjects proposed by design problem; hence, designers are expected to have various architectural experiences and backgrounds considering different educational methods and design projects they are exposed (Al-Sayed et al., 2010). Rittel & Webber (1984) as cited Chiu, (2010) found that students who lack sufficient design experience may face two challenges when they compile knowledge references to solve (ill-defined) design problems. First, they do not know where to begin gathering relevant knowledge. Second, a unique formula does not exist for a design problem. The design problem formulation depends on design knowledge and information gathered by the designer (Alhusban, 2012).

Thus, it is clear that the main issue in the knowledge of design is the direct training of the designer in an academic process; but in the discussion of experience, the designer should refer to his or her personal findings indirectly from the professional workplace (whether at the university or outside the university).

According to aforementioned subjects, on the distinction studies step, designer should specially response to design problem (specific challenge exists in design problem) within scheme using his/her creativity, design knowledge and experience (the term specific response is used because

the response for each project is unique which causes difference among designs). In this paper, the word approach is utilized for response. In fact, on distinction studies step, designer should determine his/her project approach. After selecting approach, a physical plan should be correspondingly provided. This physical plan is called special program which is different for each project, because it is derived from the project approach. Special program contains spaces (and their characteristics including dimensions and qualities) which are added to general program regarded to the project approach. In summary, an analytical diagram is presented below (Figure 4):

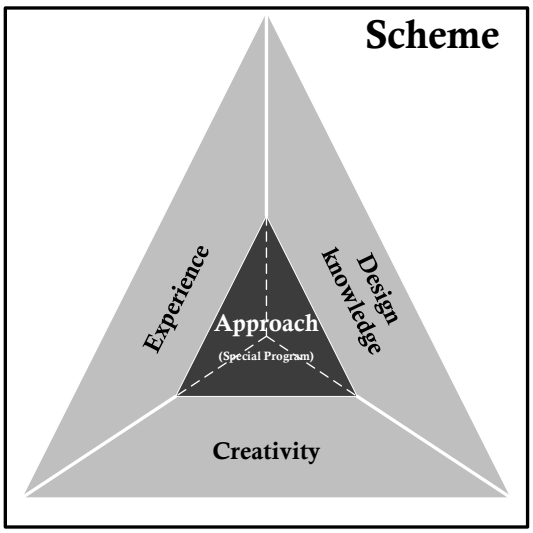

Figure 4 Distinction studies (formulation of approach, formulation of special program)

Here, example of special program to be shown (Table 4):

Table 4 Example of special program

Sub-phases	specific explanation for project	Distinction studies
Creativity	-	1. The design is inductively conducted. Firstly, significant elements of form are configured; then, others will be designed associated with those of form. In addition, a recursive design is established between the plan and the volume. When the plan and volume are accepted to some extent, it is possible to design the plan in detail. 2. Using an organizing component for the whole set 3. Utilizing the cubes in form design so that each cube set represents a specific section. 4. Symbols and signs of research centers are incorporated for volume. 5. The walkway is to be designed associated with building form, becomes prominent and visible to pedestrians. * I believe that this phase of process is very intrinsic, specific to designer, and maybe not stated in any forms even the manuscript in detail. (Ideas expressed in this section, are detailed, while the approach should be general).
Design knowledge	-	
Experience		
Approach (Special Program): Research-based design of the architecture faculty Specific research areas such as search spaces (library, site), laboratory spaces (wind and solar labs, etc.), and workshops (modeling workshops, materials) along with the number and dimension		

7. Spatial-physical program

In this section, "spatial-physical program" is discussed. As mentioned in two previous sections, a general program is obtained from cognitive studies. I addition, specific program is derived from distinction studies. In order to comprehensively define spatial-physical program that involves specific and general program, first it is necessary to review some definitions:

Cherry (1999) uses the term "programming" in his book entitled "Planning for Design," which describes it as a research and decision-making process to define the issues that should be solved through design (Cherry, 1999). Pena & Parshall (2012) stated that planning is a process that explicitly explains an architectural issue and the requirements that must be considered in providing

a solution (Pena & Parshall, 2012). It is understood from this definition that planning in general is a process in which design issues are defined. On the other hand, (Bogers et al. (2008) consider planning to identify and formulate the requirements of the employer in the construction process (Bogers et al., 2008). El Reifi et al. 2013) also consider it as a process by which employers express their demands in detail, and design team develops the plan according to it (El Reifi et al., 2013). Hershberger (2015) considers architectural planning to be the first stage of the architectural design process in which the values of the employer, users, architects, and society are identified; important project goals are accurately stated; project facts are discovered and comfort requirements become apparent (Hershberger, 2015). These opinions expressed on architectural planning have also somehow helped to clarify the definitions above, in that they consider planning as a process in which the design requirements include the requirements of the employer, the needs of the user and the values of the society. Therefore, it can be argued that the program is a very important communication tool in the interaction between the employer and the designer. Therefore, employers and their consultants tend to spend a lot of time for planning, and architects, in turn, spend a lot of time in studying and analyzing the program (Bogers et al., 2008).

Duerk, (1993), in his book "Architectural Planning," considers briefing as a process in which, on the one hand, the appropriate information for the project is provided for the designer to make the best decisions regarding building design; and on the other hand, it also meets the expectations, goals, and aspirations of the people involved in the project. This definition is chosen as the base definition in this article, because it covers all aspects of the above definitions. According to chosen definition, the authors' intent of spatial-physical program is a process in which the designer obtains the whole information about the project through collecting, organizing, analyzing, interpreting and combining in order to make the most appropriate decisions within different phases of design. The information obtained by the designer has been achieved from two sources- cognitive studies and distinction studies- in terms of general program and specific program, respectively.

In general, two theories about the performance of the program can be generally considered. The first theory considers the program as a static development document, which does not change during the design process. The second approach considers the program as a dynamic process, which is developed over several stages in the process (Ann et al., 2007). According to the categories proposed for program in architecture, it is said that spatial-physical program is categorized in the second class; it means that spatial-physical program is considered as a dynamic process that cannot be changed during the design process. An analytical diagram related to spatial-physical program is provided as below (Figure 5):

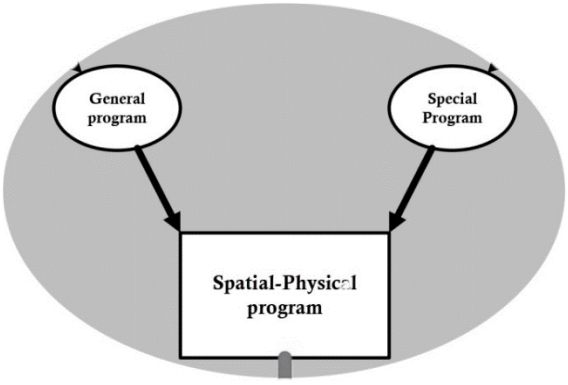

Figure 5. Spatial-physical program

Here, example of spatial-physical program to be shown (Table 5):

Table 5. Example of special-physical program

Spatial physical program	*General program: T*heoretical classes, practical classes, auditorium, administrative and service sectors *Special Program:* Specific research areas such as search spaces (library, site), laboratory spaces (wind and solar labs, etc.), and workshops (modeling workshops, materials)

When design program entitled spatial-physical program is implemented, we must step into the phase leading this program to become operational. Based on the authors, this phase, “design protocol", will be introduced in the following paragraph.

8. Design protocol

One of the problems that architecture professors always face is explaining the various factors involved in the design process to students. However, doing conceptual design itself brings a new challenge for architecture students in the design process. Because on the one hand, students should pay attention to the objective and physical factors involved in the design project, and on the other hand, they should be able to express their mental concepts in the design. Therefore, to respond to this critical issue in the design process, we need a design protocol that can organize the designer's thinking on the one hand and consider the influencing factors in the design project. To configure this protocol, we first need to find the primary factors and their component-to-component interface, as well as to know the structure of the elements themselves, so that the general framework can be formed based on the relationship of the components. Finally, the design protocol will be developed with a structure that creates order step by step and provides integration in the whole process. In other words, not only does it include the project's sub-factors, but it also regulates and creates unity in the relationship of all factors.

In this section, design protocol is presented as a final step of design process. In Webster's dictionary, the word "protocol" means "the original draft, document registration, preliminary agreement, conference record, negotiation summaries, etc." Numerous comments by scholars have been presented In connection with design protocol in architecture; Cross, (2001) believes that among all empirical research methods to analyze design interaction, "protocol study," is one of the widely used approaches which has received the most attention. As well, it has been considered as the most likely method (perhaps the only one) to reveal mysterious cognitive abilities of designers (Cross, 2001). Newell, (1966) demonstrates that the term protocol generally refers to record chronological events (Newell, 1966). Akin & Lin, (1995) has concluded the supplementary relationship between two forms of oral-conceptual data and visual-graphical data is one of the remarkable features within design protocol studies (Akin & Lin, 1995). Despite the direct definitions of the protocol in the field of architecture, Duerk, (1993) in his book entitled "Architectural programming" has defined and explained some features of the word "concept" which is very close to the authors' purpose of the term design protocol; such that it considers concept as an expression of ideal relationships which is created among the controllable elements (forms, materials, textures, colors, etc.) under the architect. As well, the concept is mentioned as patterns, design ideas or "design diagrams". Hence, concept is considered as an idea that defines ideal and proper relationships among different phases of a project. Based on Duerk, (1993), a concept may encompass the whole problem; so, concepts have been known as ideas that seamlessly assemble a variety of elements in an entirety like a special organizing idea, major concept, theme and sketch. The concept may also provide an ideal solution for a minor part of the project, such as circulation patterns. Here, it is suggested that initially a general and organizing concept is initially proposed for design; then, "sub-concepts" are to be presented consistent with the overall concept. In order to illustrate an overall concept of the project, some methods have been noted such as "expressing a concept diagram", using deductive methods, and presenting a concept scenario (literal image with text writing). To make the designer' purpose more clearly and transparently transferred to other people involved in the project, as well better understanding of pre-construction project, it is better to integrate concept scenario or concept diagrams (Duerk, 1993).

As mentioned above, in summary, the authors' intend of design protocol is writing a concise manuscript that creates a "literal image" adopted with designer' ideas on the project. This definition of design protocol matches with means that came in Webster Dictionary. The word protocol in the Webster Dictionary (2017) has been defined as the original draft, the document registration, the preliminary agreement, the conference minute, the summary of the negotiations, and so on. So,

design protocol should be extensive enough to encompass many points about the project; as well, to provide ideal solutions for any level of details within different parts of the design project.

Here, example of design protocol to be shown (Table 6):

Table 6 Example of design protocol

Design protocol	We decide to design a faculty of architecture so that research is to be considered as a main priority and education and research are defined together. So, a field of scientific search within architecture data and other areas of science (humanities, social, cultural, environmental, education, etc.) should be provided to be feasible for the students to be incorporated in architectural design. Also, the students should test their ideas to generate knowledge; consequently, they will be able to transform theoretical knowledge into practical work. It is better to use attractive forms in the building design to be kept in mind. At last, the faculty should be firmly designed as the same as laboratory and research buildings, but not be spiritless, as well as inspiring inviting and welcoming feelings for the society and citizens.

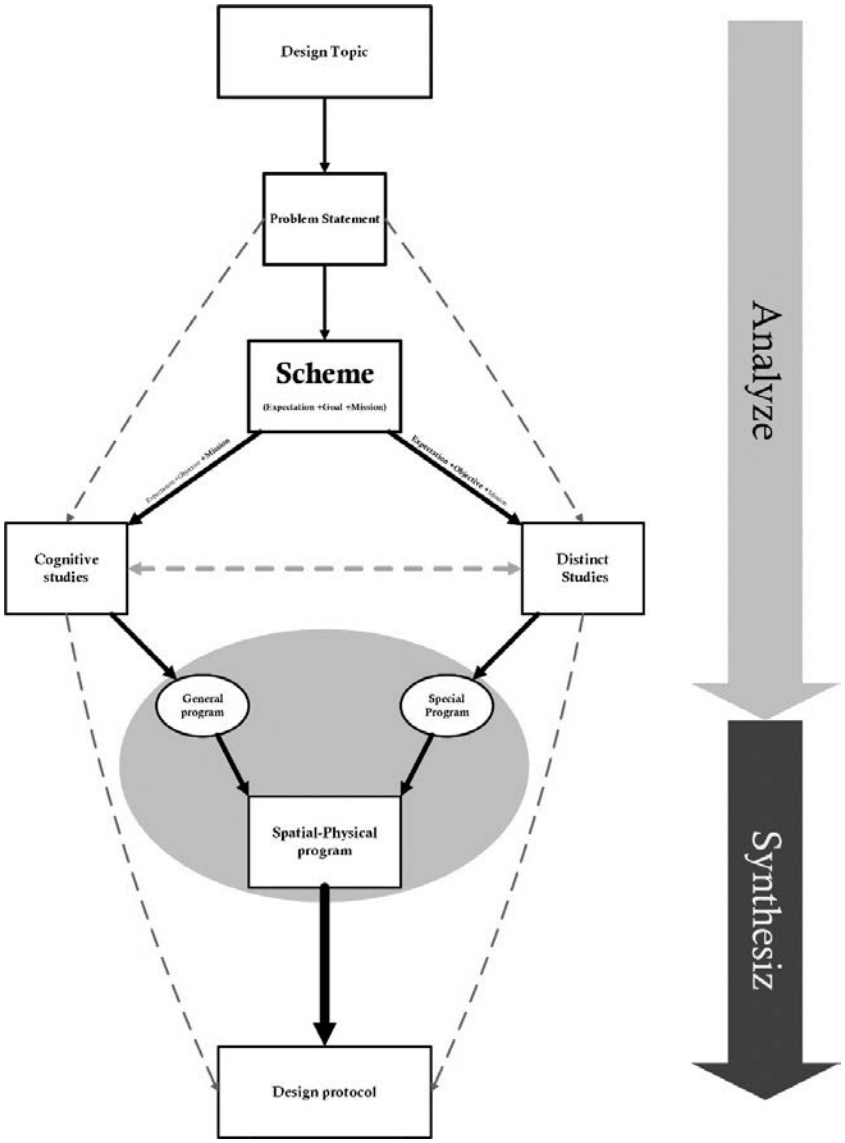

Figure 6 Research–based design process

In order to clarify the process further, a case study in which this method is conducted for the graduate students of architectural design (2) will be presented in appendix1.

Furthermore, during teaching architectural design 2 at master's degree for 3 semesters (which was conducted for a year and a half during the years 2015-2017 at Hakim Sabzevari University), through informal interviews with students, they stated having used this process, they could classify

information needed for design better. They also were able to use this information easier in designing.

Some of the student's statements are as follows:

- A student who had carried out his plan in accordance with this process for one month said that this process has led to further clarity of the matter in his mind in a way that the process of shaping the design statement for him is systematic and traceable.
- One student, after two months of the academic term and using this process, believed that the main dimensions shaping the design statement (problem statement, scheme) were identified in his mind.
- Another student, after spending two months of the semester with the use of this process, stated that he/she has found the importance of the stage of shaping the design statement and the importance of this stage has become clearer to him.
- Besides, a student who used this process for three months, stated that the factors influencing the formation of design statement - field, thematic and topical studies, and the physical spatial program - were well defined in his mind during this time.
- One student, after completing all the steps in the process, stated that the proposed process would help him to predict the design horizons and clarify the next steps of design in his mind. He also confirmed that he can more easily predict the next steps in design and therefore collect more relevant information for the next steps.

Consequently, it seems that the proposed process is a desirable way of designing and can help in the formation of design statement in the minds of students and architect designers, so that they recognize the main dimensions shaping the design statement as well as the factors affecting it and also make it easier to rotate the horizon of plan and draw the design to the end.

9. Conclusion

One of the most important aspects in design methodology and related areas of research-based design is a great deal of effort made in order to represent systematic models derived from design process, as well as proposals for structured methodologies and approaches that should effectively guide designers towards a suitable solution. However, it seems that, in practice, lots of plans move forward in an ad hoc and unsystematic approach (Cross, 2006). Thus, this research intended to provide a systematic pattern of design process emphasizing on process rather than the final product. The following paragraph has been derived from final diagram of the process (Figure 6), so, determining design subject is considered as the first step in architectural design process. The designer should achieve sufficient knowledge of design subject; for this purpose, it is necessary to initially deal with the design problem; then, analyze and configure it. In order to configure the design problem, the factors making the problem and influencing it should be also identified. Design problem may originate from context. Based on the classification by Palmer, (1981) and Lawson, (2006), factors affecting design problem have been also investigated in terms of sociocultural and human factors which individually impose restrictions on design solution. The designer configures design problem to understand it; then, he/she offers the scheme, reflecting the goals, expectations and mission of given the project. In research-based design, designer is concerned with two categories of information. The information entitled cognitive studies which are related to the project mission; and, also the information entitled distinction studies which are related to the goals and expectations of the project. The cognitive studies are the information that help the designer recognize the design subject. In fact, cognitive studies are prepared according to the building's usage comprising a checklist of spaces' names and dimensions which are provided with regard to per capita, regulations and standards specified for each usage. This checklist is called general program. Distinction studies are certain responses to design problem. Since, the design problems may have multiple answers due to their qualitative nature, so each individual designer responses distinctly to design problem and selects specific approach based on his/her creativity, design knowledge and experience. Hence, it can be concluded that distinction studies are the reasons of

differences among designs. When the project approach is selected, the corresponding physical program namely specific program should also be provided which is called Specific program. Specific program contains spaces (and their characteristics including dimensions and qualities) which are obtained based on the project approach. Finally, general program and specific program are integrated to make spatial-physical program of design including a process through which the designer acquires all information about the project to make the most appropriate decisions within different design phases. When the design program entitled spatial-physical program is prepared, designer must lead it to be operational; that is as a kind of conclusion of implemented phases which can be achieved. So, an overall pattern/idea is required that encompasses all these factors. Design protocol as an overall concept of the project" is a brief manuscript that declares designer's ideas on the project including the project overview as well as details of various phases of the project. When designing the design protocol is proposed in terms of a "text", the designer can propone a "sketch" reflecting all the ideas expressed in the previous step.

For future research, it is possible to analyze the problem statement stage as the most elementary stage in the design protocol and how to transform the design statement into architectural sub-concepts. At the problem statement stage, it is necessary to plan a quantitative and qualitative process that will give the architecture student the ability to understand the design problem and create a clear path. Since the design protocol is a written structure, its transformation into a visual and architectural form requires the explanation of regular steps with a simple and understandable construct, so turning the design protocol into architectural concepts can be considered a necessary research topic for the future.

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Appendix 1 (example 2)

Conceptual design table			
Analyze			
Problem statement			
Sub-phases	**specific explanation for project**	**Sub-problems**	**suggestion**
legislator	1. Height constraint up to 10 meters. 2. The coverage constraint up to 40 percent of site 3. Using materials consistent with walls 4. Ability to be harmonic with environment and sustainability of design	1. Mass expansion considering space limitation. 2. Limited access of site from square margin with high-density of vehicles and pedestrians. 3. Lack of easy access to the uses due to farther distance of the entrance from main spaces 4. Limitations on the use of preferred forms and materials due to its location in obsolete and historical texture of city.	1. Moving in depth along with providing coarse spaces in the floors beneath the ground. 2. Using underpass and overpass routes distributed from surrounding crossings in order to provide access of vehicles and pedestrians to the site 3. Using materials and characteristics of indigenous architecture 4. Utilizing Euclidean volumes with a legible combination
client	1. Providing live and dynamic space 2. Ability to communicate with citizens	1. Limited interaction with surrounding environment due to the lack of site proximity with surrounding streets, and comprehensively enclosed within urban time-worn and dense textures. 2. Restrictions on the use and design of walls in order to create communal spaces and inviting feeling.	1. Designing sections to create diverse and dynamic landscapes 2. Designing spaces within the site to interact and engage local residents in faculty 3. Providing an outstanding and familiar entry in the neighborhood for residents 4. Designing within the human scale
user	1. Creating exhibition spaces 2. Creating specific spaces for the faculty 3. The possibility of holding classes in open and semi-open spaces 4. Creating interactive spaces with other students	1. Inappropriate and unusual geometry of site. 2. Limits of coverage and shortage of areas for the given infrastructure	1. Environmental design priority and mass layout based on design demands 2. Considering spaces with complex and multiple uses within the site. Using the site's failure in order to define specific space 3. Using porous volumes, porches and terraces on floors to define interactive spaces 4. Utilizing temporary structures so as to exhibiting and collective spaces if necessary.
Cultural values	Rehabilitation of the area	1. Cultural heterogeneity of student environment with social and cultural structure of the site 2. Lack of easy interaction with local communities, due to neighborhood residents' resistance to communicate.	
Problem Statement: In the present study, the most important problem is site isolation within a dense and impermeable texture which on one hand makes the possibility of visual and physical relationships with surrounding environment through the walls impossible and adversely			

affects the process of interactive inviting the audience. On the other hand, access of vehicles and pedestrians have been restricted and reduces the interaction with environment.

scheme

Sub-phases	**specific explanation for project**	
expectations	-	Creating a live and dynamic environment to engage students and residents in the faculty of architecture.
Goals	-	Rehabilitation of old textures and contribution to the development of cultural and social infrastructures with the help of faculty of architecture.
Mission	-	Constructing the faculty of architecture that meets project goals despite limitations.

Scheme:

Constructing a familiar space in form of faculty of architecture in order to establish a base for development of cultural and social characteristics and texture rehabilitation.

Cognitive studies

Sub-phases	**specific explanation for project**	
Regulations and standards	-	-
Per capita	-	-
Subspaces	-	-

General program:

A List of spaces within architecture faculty such as theoretical classes, practical classes, auditorium, administrative and service sectors as well as the number and dimension

Distinction studies

Sub-phases	**specific explanation for project**	
Creativity	-	1. Emphasis on design within human scale 2. Priority of environmental design 3. Using floating spaces 4. Using Euclidean volumes with a legible combination 5. Cross design along with use of semi-open spaces within the floors 6. Using traditional architectural features, such as arrays in viewing to create a familiar environment in order to provide a sense of community. 7. Interaction with surrounding environment with the aim of developing cultural and social characteristics in order to achieve sustainable development goals.
Design knowledge	-	
Experience	-	

Approach (Special Program): Designing architecture faculty to create an interaction between residents and students

Specific program: providing facilitating interactive spaces such as exhibiting spaces (exhibition of handicrafts, local products, and students' works, etc.), gathering spaces (open and semi-open spaces within the site), educational and cultural spaces (spaces so as to discuss, workshops for common activities between residents and students, workshops to train individual, cultural, and social skills, as well as workshops so as to train students with local residents' art and vice versa, amphitheater, etc.)

Synthesize

Spatial physical program	**General program:** educational spaces (studios, theoretical classes, workshops and laboratories), service, welfare, and office spaces. **Special Program:** exhibiting spaces, gathering spaces, educational and cultural spaces
Design protocol	We decide to create a familiar environment within an old physical and cultural texture. A modern environment which is intimate and lovely for people using indigenous architectural features. A charming and outstanding entry which attracts all people which transforms that space into a local symbol. Environmental spaces with a variety of uses and placid and solemn volumes with a legible combination. These areas do not push back the audience and the perception is not complicated. Indeed, this design provides an interactive space to be simple and constructive for the students and residents. In this regard, the architecture student will be practically situated in a real work out. In addition, educational process and space are defined from a new perspective. On the other hand, the residents feel close to it while influencing from different cultural and social areas.

Resume

Shahab Abbaszadeh, I graduated in 2003 with an M.A. in architecture. Then I participated in the design competition at Herat University, and in 2004, I designed two faculties of economics and law at that university. Consequently, I joined the University Putra Malaysia to complete my Ph.D. I was awarded for selecting my Ph.D. thesis as the best thesis in architecture in South Pacific Asia by the Ministry of Science, Research and Technology in 2008. After getting my Ph.D., I was a permanent university lecturer at the Architecture Department of Hakim Sabzevari University in May 2010. After 11 years of working as a university lecturer, designer, and researcher, I got many valuable achievements, such as; "Supervised more than 50 postgraduate research theses in architectural studies, Published more than 70 journal and conference papers & four books, Received letters of appreciation for my high marks in teaching in several semesters, Awarded as a well-known professor in teaching Design Process, Research Methodology, Conceptual Design, and Design Studio courses, Nominated as the top professor in my faculty for more than six years, Assigned as the reviewer in several top-ranked journals relevant to my research fields, such as the Journal of Housing and the Built Environment, Supervised eight practical and applicable research–design projects for different state and private organizations in various cities and provinces such as the municipalities of Sabzevar, Kashmar, Shirvan, Tabas, and City Council of Razavieh towards solving architectural and urbanism challenges and issues (I conducted five research - design projects and contributed to two research projects), Leading some university campus projects., I acquired the rank of associate professor in 2017, which introduced me to the youngest associate professor at the university. Shortlisted for the final stage in the category of sea-level rise and nominated as one of the best projects in international competition, the Jacques Rougerie Foundation international architectural competition, in 2021 in French.

This is Behrooz Khosrowjerdi, a graduate of the field of architecture at the master's level, a researcher, and an architect designer. I started my studies in architecture in 2009 at the undergraduate level, and in this regard, I focused my analysis on the spatial qualities of children; as a result, I completed my thesis on the topic of designing quality-oriented spaces for children. After that, I started my master's degree in 2014 at Hakim Sabzevari University, where I limited my studies to quantifying architectural factors and the effects of digital spaces in environmental psychology. In this regard, I chose my topic on the quantification of factors affecting the design process, which led to the publication of an international and a national article. Currently, I am continuing my studies in the field of artificial intelligence application in the research-based design process.

This is Zohre Sadat Seyedmoradi. I started my bachelor's degree in architectural engineering in 2010 at Hakim Sabzevari University and finished it in 2014. I immediately studied for a master's degree, and in 2016 I graduated with a master's degree from Hakim Sabzevari University. In my master's, I did research work and completed my thesis titled "Designing the Faculty of Architecture and Urban Planning with a research-based design approach." During my thesis, I wrote some articles titled "To Development an Analytical Model for the Formation of a Design." "Scenario" in the Research-based Design Process in Architecture" has been published in an international journal. Currently, I am also doing research in the field of the research-based design process.