An Effective Decision Making Model to Aid Evaluation and Selection in Architectural Design Process

Validity of Scientific Techniques for Decision Making (Decision Aid) Used for Selection in Early Phases of Architectural Design

SeyedAbdolhadiDaneshpour[1], SasanHosseini [2]

[1]AssistantProfessor inDepartment of Urban Planning and Design–Iran University of Science and Technology (IUST).

[2]Ph.DCandidate inArchitecture–Iran University of Science and Technology (IUST).
S_hosseini@iust.ac.ir

Abstract: Architectural field is facing inevitable changes. Technological advancements such as GIS and BIM plus other specialized analytical tools including environmental, structural, mechanical, security, and digital modeling have introduced new changes in architectural design. The new technologies mandate changes in the design processes currently in use in design workshops (atelier). The changes are to be introduced as multidisciplinary activities to all design related fields of a given project. The requirement for such undertaking is the interactive capabilities of the current systems. The current design processes prevalent in architectural workshops are considerably behind the current trends and have failed to keep up with the rapid technological changes and scientific development in various fields. Information domain is expanding in many dimensions in various disciplines. The architectural models used in design workshops have not been fully developed to help applyingthe relevant information to decision making processes.Linearity of the traditional modelsof decision making that are currently applied in architectural design together with step by step decision making process havemade the traditional approaches obsolete.Linear decision making processes have created a dilemma called *Data Relation Threshold*. This is a state when a decision is made based on relevantpast decisions without having any relation with anything other than the decision itself (when considering the common variables). This article does not propose a new digital design aid. Its objective is to provide a decision making system for architectural design based on the current technologies and methodologies available to the design process. Most of these methodologies are processes that architectural designers apply as part of their mental activities. Human brain is capable of processing maximum 7 subjects,concurrently.When brain encounters with more than seven issues, it will not be able to adequately process than and may end up in confusion. Computers, however, can concurrently perform a higher number of complex processes. The development of decision making process that makes measurement and decision making possible may lead to a dynamic database system that is able to perform as a base analyzer.

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Introduction

Traditional linear design processes have an inherent problem that direct the design processes only in one direction. This problem does not allow the utilization of existing data to search through probable cases. Using a traditional design approach is analogous to solving modern day problems with outdated approaches. Another basic problem with traditional approach is related to the practical aspect of the traditional linear processes. This problem is related to project information management and may put the effectiveness of architectural activity in question.

Architectural decision making takes place in contiguous steps without open standards for data transfer amongvarious databases.Consequently, the resulting process lacks adequate efficiency. Data collection process produces information as theoutputof each step of designing process. Because of a lack of connectivity, each step of the design process reproduces the information related to the previous step for its own processing. This information reproduction is repeated in every step of an architectural design - a design process that is common and prevalent in most architectural firms.

Research Significance

Architectural design involves data collection, analysis, and interpretation. What ultimately shapes and enlivens architectural designis the designer's innovation and talent in using the available information. Lack of data connectivity makes their relations and associations with the design unclear. Yet, the volume of data may interfere with the creative property of a designer resulting into lack of confidence and difficulty in decision making.

Most experimental studies on design process include a step called *design testing*. Analytical studies of design tests usually collect graphical and verbal information.These two types of information complement each other in solving design problems but the decision making process itself is not taken into account. The time lost in searching for a solution to a given problem together with the process of finding the solution is normally hidden. Yet, they can contribute to decision making process.

Some researchers, including Thomas A.Marcus (1969) and Thomas W.Maver (1975), had comprehensive views on design process. They thoroughlyexamine the design process. They includeddecision making in the design process but did not touch the decision making approaches.

The objective of this study was to find the effective factors in decision makingprocess as applied toarchitectural design. This study attempts to improve the future architectural design by examining the science of decision making and its capabilities as applied to the field of architecture.

This study is important from four points of view:

1. Principles set the direction of architectural decision making. They provide a base for further discussion about every architectural decision.
2. Intellectual designers and critics rarely base their decisions and judgments on a single criterion or a clear and definite theory.
3. Authors put most of their efforts in form of self-criticism. They review, combine, establish, eliminate, add, correct, or test parts of their work through this self-criticism.
4. The final and perhaps the most important point of this writing is the introduction of decision making science into architectural design field.

Research Objectives

The important objectives of this study according to the problem definition were:

1. Identification and definition of quantitative and qualitative factors and variables that are effective in the decision making at the formation of concept;
2. Modeling of the governing relations among factors and the determination of the impact on each variable;
3. Quantifying and weighing effective factors and variables that influencedecision making at the formation of the concept; and
4. Modeling decision making process at the formation of concept and presentation of a decision making model.

Research Hypothesis

- Various dimensions of architectural designare interrelated and it is possible to systematically detect and record their relations and dependences.
- Systematic recording of the relations and dependences together with classification and ordering of the effective factors on decision making plus the integration and clarification of the selection process (decision making) can provide a hierarchical and analytical model plus a structured framework for decision making in architectural design.

Research Questions

1. How the optimum solution is selected for a design process? (How decision making takes place at the formation of the concept during the early stages of design works?)
2. How effective key indexes are identified and selected in the process of finding the best option? What is the effective framework in selection of key indexes?
3. What decision making methods could be applied to architectural design? How these methods may be applied to architectural design process? (Is decision making process capable of addressing the selection of an architectural option?)

Architectural DesignProcess

Design Process

Architecture is a multi-dimensional subject. It attempts to accomplish unpredictable new compositions or outcome from mixing its sub-dimensions or lower divisions. This mixing process requires a suitable approach (Golparvar as quoted from Pakravan and Amir Montaghamy, 2010, p. 452). Architects view architecture a creative process that involves expression of a design, idea, or thought which forms in architecture mind together with a given influence and/or excitement that tend to manifest in form of a structure (Von Meiss, 2004).

The main question here is whether architectural design or the process of creating an architectural form is merely a mental process that cannot clearly be explained in general terms.Or, is it possible to identify given and definite processes for architectural design by thinking about the views of an architect and the way they are presented in design works?

Individuals who have discussed design process in recent years have identified various phases. Most designers consider design process as an intuitive work that escapes explanation because mental faculties do not work merely in intellectual forms or practical logics made of identical packets of information. Design process extends in an intuitive and sensational way deep inside the brain and beyond one's thinking property. It functions through an immeasurable mental-psychological apparatus at a level higher than rational and developed perception (Ando, 2002).

Research Background and Literature

Before World War II, design activities would take place in the form of an unexplainable intuitive process. Design process depended on designer's abilities and decision making possibilities. A designer would act like a black box, taking the input data through a mysterious process in order to present a presentable output. Design was an undistinguishable internal process stemming from inspiration and intuition taking input from designer's experience and decision making capability.

The aftermath of World War II produced many changes in the design process and its ensuing problems, during late 1950s and early 1960s. Research on design started when design faced many complicated problems resulting from the crisis in Europe after World War II. The circumstances made it impossible to solely rely on the traditional and common design processes which depended on magical abilities, creativity, and artistic innovation of designers.

The traditional design process was no longer capable of addressing new wide spread design issueson a mass production scheme. Design users demanded the right to supervise the design process. They demanded assurance that the design process would comply with the pertaining regulations and required the possibility to monitor its performance. In response to the requirements of the time, many theoreticians of 1960s and 1970s engaged in coming up with proposals for logical, scientific, and systematic design processes (Nadimi,1999).

Various systems and disciplines such as design, computation, planning, and engineering systems have influenced architecture. However, thedesign process as a field of study remained unnoticed until 1950. Most of the proposed design processes not only did not address decision making problems, but also they ignored the schedulingof the main activities within the design process including analysis, composition, modeling, evaluation, reprocessing, and research (Rosenberg and Eckles, 1995).

Former research approachesused in architectural design processing included:

- Designer Interviews (identifythe influencing factors on decision making)
- Observations, notation, and case studies (identify the influencing factors on decision making)
- Research contracts or agreements (often for fictitious projects because of the difficult circumstances in carrying out contract terms)
- Controlled testing (tests that are carried out under controlled management or lab conditions. These tests are performed on real subjects in a given case. The collected information is recorded and analyzed).
- Model testing (attempt to illustrate human thought with the aid of technology)
- Theoretical analysis of thoughts (relevant to the nature of design thoughts).

British Royal Association of Architects divided design process into four phases in *Architectural Practice and Management Handbook* (1965): solicitation, evaluation, development, and presentation.

Lawson believes that data collection is less taxing on mental capacity than problem solving; therefore, there is a tendency to delay the movement from phase 1 to 2. Professional designers never succumb to this urging, because they have to make a living by their work. However, most of students normally give into this tendency and such a pattern is often interpreted as unproductive procrastination.

A shocking incidence is when a designer learns that the problem was not completely defined (phase 1) right at the presentation of the design to the client (phase 4). An encounter most designers have experiences. What has escaped Lawson's attention is the time lost in search of finding an answer and the way the answer is found for the problem. Adecision making process could address these two issues.

Sub-processes or initial drawingstep of a design process often has a logical sequence of activities including analysis, division,composition, and evaluation. Figure 1 shows the general design cycleproposed by Rosenberg and Eckles(1991).

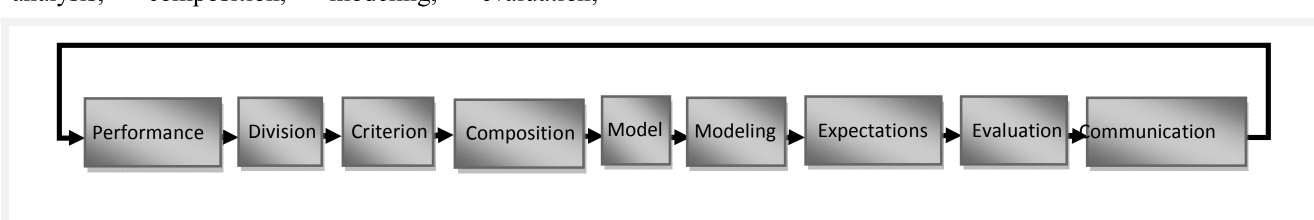

Figure 1- Rosenberg-Eckles Design Cycle

Some architects believe that design processrelies on personality and skills of the designer (Akin, 1995). Two well-known academics by the name of Thomas A.Marcus (1969) and Thomas W.Maver (1975) provided a more descriptive chart for the design process (Figure 2). They showed that a complete design chart requires a *chain of decision making* plus a *design process* or *design formation*. They believedthat the chain of decision making includes analysis, composition, evaluation, and decision making. These steps are to be performed at certain times in a design process with each step having to deal with more details than the previous one (phases 2, 3, 4, and 5 in *British Royal Association Handbook*). Marcus and Maverhad broader views of the design issue and defined a more comprehensive design process. They agreed on the existence of decision making in the design process but failed to mention any decision making approach.

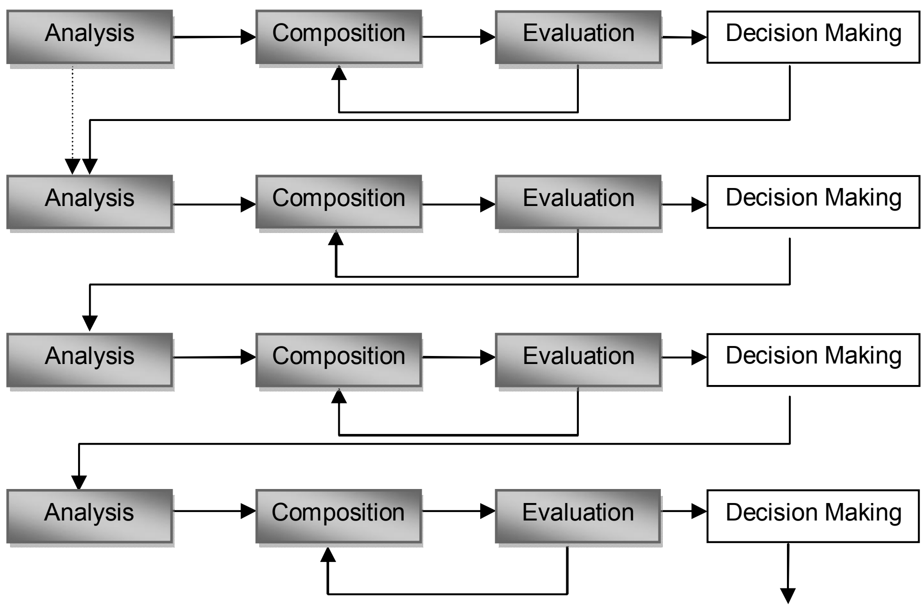

Figure 2- Marcus-Maver Design Process Chart

The Origin of Design Idea

Alexander (1964) in his book of *Notes about Form Composition*based identification of design problems on making a list of the design requirements and defining their interactions. He developed a diagram to present the relative strength of the requirements by labeling their interactions as positive, negative, or natural. This information is entered into a computer program for processing and breaking down the case into simple logical problems. His proposal was criticized because of the difficulty in preparing a requirement list at the beginning of the design process and deciding on the interrelationshipsof the listed requirements.

Jones (1992) agreed to the difficulty of starting a design process because of the insufficient information to begin with. He proposed a model consisting of three modules of divergence, change, and convergence. A designer starts a design work with a divergence approach looking into the description of the problem. The objectives and limitations of the problem are identified in this process. In change step, the outcome of divergence searches is used to break down the problem into sub-activities, and define the limits for each one. Finally, the convergence step involves in limiting the number of options created in previous steps.

Rowe (1987) tried to use case studies to identify an inner logic in design and architecture for decision making.His simply observed that designers usually used analogy to start design processes. The designer'sanalogy was based on the earlier experiences and/or an approach taken for a similar problem. He observed that the analogy could start the design process by activating a series of events, which in turn determine a series of smaller events. Rowe discovered that the approach designers used to organize the space of a problem influenced the direction of design works. He also observed that architects were more incline to stick to the initial ideas.

The requirement for initial organization of a design problem is reflected as "guess-analyze" in the proposed design model by Hillier (1972). This model includes a module that determines the conceptual theory that initially organizes a given problem. This conceptual theory is analyzed to determine whether it could be used to develop a design that could address the plan requirements. In this model, the guesswork used for the designand specification of a problem works concurrently.

Duerk (1978) proposed a concept for formation of ideas as the "initial generator" used by architects. He added the initial generator as the starting step to the designing process proposed by Hillier. Dark's initial generator is conceptualized based on his design process studies of a group of residential buildings. His observed that designers relied on their mental properties instead of logical analyses of the design problem. The initial generator does not produce a comprehensive list of limitations. It is rather an approach to start the problem solving based on a group of concepts such as the nature of the site, preservation of social patterns, and certain other public values. Hence, the guesswork takes place by consideringthis information. The guesswork could be tested against the design requirements. Dark described the impact of testing on a number of solutions as "variety reduction".

Dark's approach inproposing a given idea based on the initial perception or innate understanding of the problem is similar to divergence, change, and convergencesteps proposed by Jones. Dark's approach evaluates the original idea to determine its relation with the problem. Every suggestion is considered to conduct more studies. Designers can rapidly reduce the number of possible options by selecting a limited number of initial generators. This approach is better described as the organization of an unorganized background.

Lawson (1994, 2006) believed that this type of process is the main idea for or the directing principle of a design work. In his view,these approaches imposed limits on the problem and reduced the scope of its probabilities. Lawson made this conclusion based on the outcome of his studies on activities.

Brown (1992) described an approach where any given idea is assumed valid unless proved otherwise. Brown's proposal was based on Carl Popper's studies. Breakthrough is the term widely used to describe this type of approaches. Breakthrough approaches are training or solution seeking approaches. They are formed based on experience and conjecture/general guiding principles rather than theory. Rowe (1987) in his book titled *designing thought*considered breakthrough design processes as ways to address problems based on earlier experiences or conjecture/general guiding principles.

A selected breakthrough approach defines a series of limitations which, in turn, determines the testing and evaluation approaches for the design works. These limitations determine the initial spatial construct of the problem. The selection of breakthrough approach influences the future direction of the design. Shan (1991) suggested that designers have to analyze the conceptual processes in order to obtain an analysis framework to provide a reservoir or library of selection strategies. Newell, et al. (1957) defined breakthrough as any principle, method, or arrangement that may reduce the number of options in search of a suitable solution.

Measurement: Design Judgment

Design solution elements may concurrently assume a part of the problem. How well a design solution could address a complicated problem? How can we select the correct answer out of many solutions?The answer to these questions depends on how well we can measure the successfulness of a given design process.

Archer proposed a well known numerical and detailed model to address disarrayedscales. He reluctantly confessed that parts of design measurement remain mental. However, he uses relative scalesto measure design satisfaction in his fully organized apparatus (1996). He believed a scale of 1-100 could be used for mental evaluation. The resulting data, then, could be used as a true relative scale.Judges are asked to avoid scaling in this system. They are prohibitedto use interval scaling. Judges can only use absolute zero and fixed intervals. Archer did not specify the best way to select the judges or the best way to control the circumstances. It appears that he has left the domain wide open.

Value Judgment and Indexes

Lawson believed that the tendency to use accurate measurement techniques in designprocess was unjustified. We have more computation techniques in high level scales, such as relative and interval, which permit absolute judgments.

Computation Accuracy

What a designer needs is a feel for the meaning behind the numbers and not the accuracy of the computation. The main point for a designer is the strategic decisions rather than the accuracy of the computation.

The difficult task for a designer is assigning numerical values to criteriain such a way to create a balance between them and some other unquantifiable factors. One issue to bear in mind is the fact that numbers and figures may give importance and value to minor and insignificant factors.

Value Judgment in Design

Value judgment is inevitable in design because not all design variables are measurable by the same scale. For example, we have to create a balance between ease of use and safety in the design of an electrical instrument; or, balance portability against power and durability. We may judge a design based on the overall satisfaction of the pertaining factors. However, establishing relationships between these factors may still be a difficult task.

Architectural Decision Making As a Process
Decision Making Science

Simon (1977) defined three processes for decision making: information, design, and selection. Tubran (1990) later added implementation to these three processes. There is a flow of activities from information to design, and then to selection. It is possible to return to the previous step at any step. The information phase examines the true environment to identify and define the problem. The design phase involves system modeling which simplifies the reality and defines the relations between variables. The model is confirmed by evaluation criteria (Awad, 1994). The selection phase of the model provides a solution to the problem. This solution is to be tested until it could be justified. The solution is ready for implementation if justified. Asuccessful implementation indicates that the main problem is resolved. An unsuccessful implementation returns the process back to the beginning of the modeling cycle (Tubran, 1990).

Management Information System (MIS) was introduced to scientific and management fields with the objective to provide the required information on timely and orderly fashion. Decision making in MIS is a part of solving the problem (KRowenke, 1992, p. 158).

Decision Making Steps

First step - Identification of the problem (opportunity): A collection of information obtained from various sources help the identification of the problem or opportunity. This step is initially supported by Executive Information Systems (EIS). The role of EIS is to examine the environment, produce the required reports, concentrate on the main criteria, and provide a hierarchical examination of the subject(s). An Expert System (ES) can help the design of information flow and interpretation of the information. Acombination of ES and neurological computations may be more appropriate in case of unclear (fuzzy) information. Natural Language Processor (NLP) can be used to summarize the information (Turban, 1990, pp. 3-22).

Second step - Analysis: The main question after identification of the problem is what to do with the problem. This step involves analysis with quantitative and qualitative methods (and/or a combination of the two). Decision Support System (DSS) can perform quantitative analysis and ES can aid and support qualitative analysis.

Third step - Selection: The analysis results of a problem and/or opportunity may produce many solutions. DSS or Group Decision Support System (GDSS) can aid the selection process of the a suitable solution (ibid, pp. 13-41).

Forth step - Implementation: DSS and ES can help the implementation of the selected solution.

The decision making research shows that the influencing factor in accurate decision making is the techniques a decision maker uses to evaluate the available options. Decision making generally involves probability. Therefore, decision making skills rest in a person's ability to increase the differences between available options (Maleki,2004, p. 14). Parts of the decision making process may sometimes lead to wrong decisions, e.g. inadequately defined solutions or collection of inaccurate information. Inappropriate decisions may not be the outcome of the decision making process, it could rather stem from the mental disposition of the decision maker or his inability to select the proper option.

There are four ways for problem solving: solving, resolution, dissolution, and absolved. Solving approach selects the best option. The objective of resolution approach is to find a satisfactory solution which is not necessarily the best option. It is possible to ignore certain conditions in the last two approaches. Architecture faces a wide range of design problems. Design may encounter irresolvable problems if certain delicate problems are ignored in the design process. Therefore, architects normally take solving or solution approach to address design problems. This limitation forces designers to look for the best tool for decision makingfrom numerous alternatives.

Architectural Decision Making Requirements

Designers created their work based on what is left from their predecessors.Designers were forces to make more decisions on their own when rules and traditions were gradually discontinued. Earlier, designers could still rely to some traditional rules to aid their decision making, but nowadays, the last remaining traditions are to be abounded leaving designers confused and single handed(Alexander, 1971). Designer shall create forms without resorting to trial and error. One perquisite of any design works is that others should understand the resulting forms.A single person is now expected to complete the architectural works that once took many generations.

Human knowledge and creative capacity in solving complicated problems limit the number of concurrent factors onecan consider and the complexity of the decision one can make. This limitation puts the number of issues human brain can process concurrently at any given time at seven. Brain cannot function properly and end in confusion when the number increases beyond seven.Therefore, Decision Support System (DSS) is developed to aid us in decision making. Decision making process has organized brain and mental capacity to provide a systemic thinking process. Decision making processes are tools in the hands of decision makers. These tools help them organize what is going through their minds in order to produce the proper output.

The importance and value of decision making in design could be attributed to the fact that criticism and organization of an event can simplify its understanding. Designers are looking to answers to the following questions when they examine an architectural work:

Why this building is designed and constructed in this way? Who designed this building this way? What is the influence of culture or subculture on the architectural design of a building? Peter Collins (1971) grouped architectural criticism into four classifications: 1) design process, 2) competitive evaluations, 3) controlling evaluation (revision), and 4) journalism.

Decision Making and Architecture

Many decision making systems proposed for architecture are based on three prong definition of Vitruvius, i.e. functionality (useful), strength (solid), and beauty (beautiful). These systems work based on the idea that a good architecture has to be strong or solid. Strength isa positive feature of a building when it can fully serve in providing the required functionality, inspiration, and motivation for extra activities.

John Ruskin used the three principles of Vitruvius to state that a building must have 1) a good functionality and fulfill our needs the best way possible; 2) present itself very well and clearly display what it was meant to be; and 3) have a good appearance and provide pleasure for its being regardless of what functions it was supposed to satisfy and what it was to present (Ruskin, 1851, pp. 39-40).

Hillier, Musgrove, and O'Sullivan (1972) proposed another system which was different from Vitruvius concept or any other mechanisms based on Vitruvius system. This mechanism considered all the requirements of the twentieth century. A building in this mechanism is expected to regulate the climate, behaviors, culture, and resources. The regulating view of an architectural work involves both functionality and positioningaspects.

Research Methodology

The present research is a discovery-practical study. Several methods are used according to study objectives and requirements. Thisstudy used compilation method in wide variety of design considerations in order to carefully examine the statements made by architects about architectural forms. This approach was taken to help the collection of effective and key criteria thatsupport a better understanding of an architectural work. This approach also aids the collection of constructive factors in a given architecture based on the initial data.

Research Design

The proposed study approach is presented after classification of criteria and examination of their correlations. The proposed option selection approach is a model developed after studying decision making techniques, the nature of architectural design, three AHP techniques, and VIKOR and PROMETHEE I methods. Some advantages of VIKOR method was used in PROMETHEE. PROMETHEE is a simple method with many applications. However, this method is unable to provide the final ranking. The study proposed approach uses positive or negative ideal responses in VIKOR method in order to address the ranking problem.

Data Collection

The selectionof the best design out of many options requires the identification of evaluation criteria. Development of a decision making model involved several steps. We studies past research and existing literature on subject. We, then, interviewed experts and designers in order to determine the influencing criteria. Next, we developed a questionnaire and distributed it to architectural experts to identify critical criteria that may affectarchitectural design process and determine their weights.

The expert team identified options and key criteria based on underlying conditions for decision making. If the set of options is in the form of $A = \{a_1, a_2, \ldots, a_m\}$, the set of criteria is defined as $F = \{c_1, c_2, \ldots, c_k\}$. The evaluation matrix included ranking of $f_j(a_i)$ for every option of a_i with criteria c_j.

This study used qualitative and quantitative criteria. Quantitative criteria for each option were determined from the library data. Qualitative criteria were determined by brainstorming. The resulting evaluation criteria were converted into numbers from 1 to 9 using a Likert scale before input to the evaluation matrix.

Criteria weights were determined by Analytical Hierarchy Process (AHP) method. Pairwise comparison tables of criteria were prepared and distributed to experts and designers for comments.

The inconsistency rates for all the tables were calculated. Tables with inconsistency ratesover 0.1 did not enter into calculations. Expert views were incorporated by using geometric mean in order to deduce the weight of every criterion.

AHPmethod enables decision makers to determine the reciprocal and concurrent effects of complex and uncertain situations. This flexible model helps group members to form their ideas, define problems through proper hypotheses, and reach a desirable answer. AHP correlates personal judgments and values in a logical approach. This method provides a hierarchical structure of individual knowledge and experiences. A desired judgment is then made based on experience and logic (Amiri, 2010).

Preference Function

One preference function is developed for each criterion. This preference function converts the difference between every two options and a given criterion into a number between zero and one which is the preference degree.

Preference Index

PROMETHEE method calculates the preference index for every two options in the form of a set of $p_j(a,x)$ multiplied by the weight of each criterion w_j. The preference index for every option is calculated at every criterion relative to other options (equation 17). All indexes are entered into a new matrix with *K* rows and *M*columns; with *K* representing the number of criterion and *M* representing the number of options.

$$(17) \quad \pi_j(a) = \sum_{x \in A} w_j \times p_j(a,x) \qquad \forall j = 1,2,\ldots,k \;,\; x \neq a \;,\; a \in A$$

Where$\pi_j(A)$ is defined as the preference index for every option$A$with criterion ***j***with respect to all other options.

Distance between Options and Ideal Solution

The distance between options and the ideal solution are calculated to obtain the sum of the distances in the following equations:

$$(18) \quad S_i = \sum_{j=1}^{n} w_i \, (f_j^* - f_{ij}) \big/ (f^* - f_j^-)$$

$$(19) R_i = max_j \, w_i \, (f_j^* - f_{ij}) \big/ (f^* - f_j^-)$$

WhereS_i represents the proportional distance of i^{th} option from the positive ideal solution (the best composition) and R_i represents the proportional distance of i^{th}option from the negative ideal solution (the worst composition). The high ranking solution is based on the value of S_i and the lowest ranking solution is based on the value of R_i.

VIKORQ_iCalculation

The value of every ***i***is calculated by the following equation:

$$(20) Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + (1-v)\left[\frac{R_i - R^*}{R^- - R^*}\right]$$

Where $R^- = \max_i S_i$, $S^* = \min_i S_i$, $S^- = \max_i S_i$ and $R^* = \min_i R_i$ .The weight of v represents the strategy of the majority who agree with criteria or the maximum group utility.

$\left[\frac{S_i - S^*}{S^- - S^*}\right]$ represents the proportional distance of the negative ideal solution of i^{th}option or the majority agreement for i^{th}proportion.

$\left[\frac{R_i - R^*}{R^- - R^*}\right]$ represents the proportional distance of the ideal solution of i^{th} option or the disagreement with i^{th}option.

Q_i leads to majority agreement when v is higher than 0.5. Q_i represents negative views of the majority when v is lower than 0.5. Q_i represents agreeable attitude of the evaluating experts when v is equal to 0.5.

The application of these approaches in the present study is illustrated in figure 3.

Conclusion

This study provided research data, findings, and their analysis and interpretation. The relations between factors were analyzed. After data collection from the questionnaire filled by experts, the results were analyzed by factor analysis method, and then the effective factors were obtained. In the next phase, every factors and variables obtained from the previous phases were weighted with the help of analytical hierarchy process and the final hierarchical decision making model was constructed.

If we could model the evaluation and selection processes of architectural design option and determine the relations between effective factors, we can facilitate decision making and decision analysis for selection of architectural design option. Based on this hypothesis, we can identify and test effective factors in analysis and evaluation of architectural option. Research hypothesis were complemented by four secondary hypotheses.

Obtaining three important models and estimation of their minimum confidence coefficients such as minimum significance coefficient, chi-square fit index, chi-square to degree of freedom proportion, goodness of fit index, and inconsistency rates confirmed the primary research hypothesis, i.e. the possibility of constructing an effective model for group decision making. Authors will examine this model and the results will be made available to the interested groups.

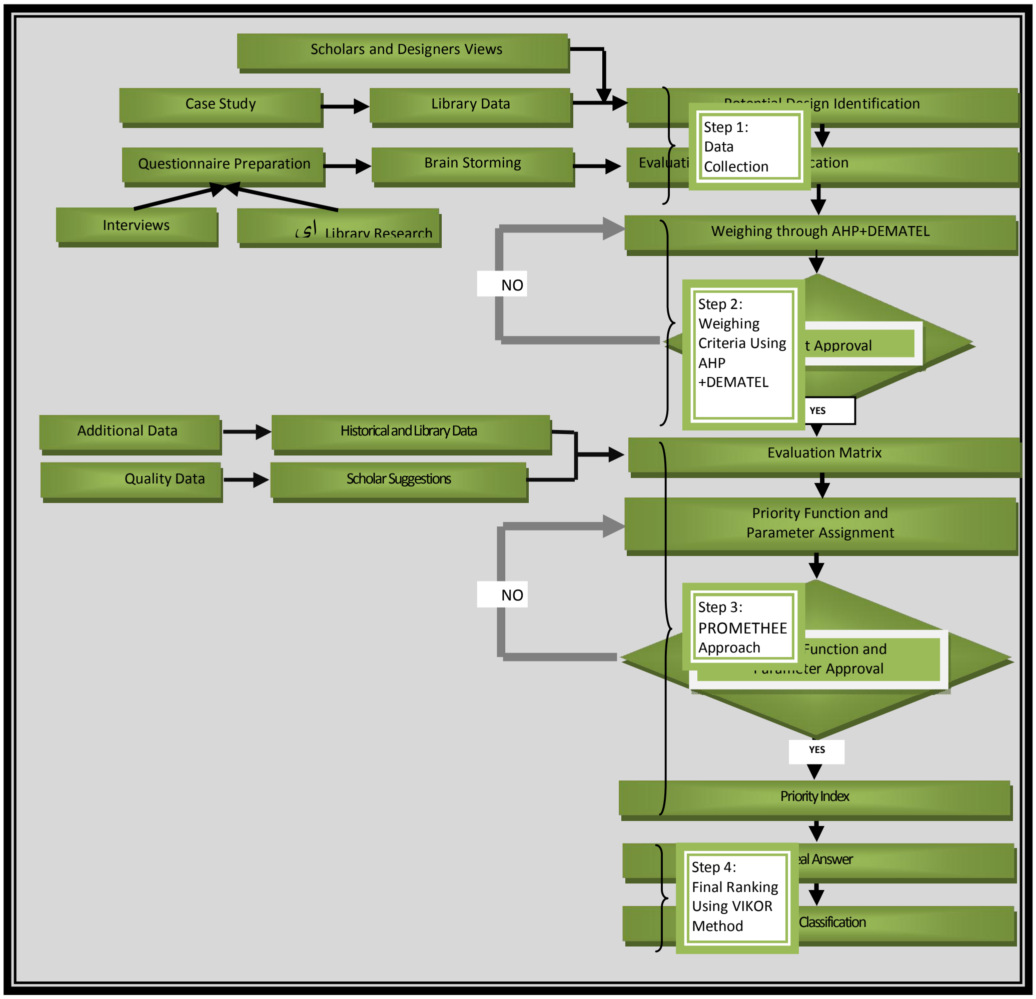

Figure 3 - Research Flowchart

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