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**Research Paper**

# Effective Components in Assessing the Creativity of Novice Architectural Students

**Saviz Tayyah [1*] Fatemeh Mehdizadeh Saradj [2]**

[1] *Department of Architecture, Rasht Branch, Islamic Azad University, Rasht, Iran*
[2] *Faculty of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran*

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***Abstract***
*As one of the essential tools for architecture education, one can refer to the criteria for assessing the creativity of architecture novices during the architectural design process and in the final design product. The components required for architecture novice creativity assessment are extracted by reviewing relevant previous studies and surveying 116 experts and professionals using an open-ended questionnaire. Next, the effectiveness of the components in the architectural design process and the final design product is verified using a researcher-made closed-ended questionnaire. The data accuracy and correlations between the variables are examined using Friedman's test and Spearman's correlation coefficient in the Smart-PLS software. The research results presented the subcomponents of stages in the fluid architectural design process: the recognition and perception stage (including the right and comprehensive understanding of site potentials and climatic and environmental information), imagination and unconscious mind stage (with emphasis on the uniqueness of the idea), in-between stage (abstract thinking and use of metaphor and amphibology), consciousness (intellection) stage (coherence in design, attention to primary data and the future), and from latency of the design idea to the final decision based on the individual evaluation. Attention to each mentioned component within these nonlinear and flexible stages in the architectural design process improves the creativity of architecture novices. Thirteen criteria were obtained for assessing the creativity of the final product of architectural design, which includes all effective physical, conceptual, and spatial subcomponents.*

***Keywords:*** *Creativity assessment, Design process, Creativity promotion, Architecture novices.*

## INTRODUCTION

In design, creativity is regarded as one of the important features of cognitive development and is considered a key feature required for innovative design solutions (Jones, Rodgers, & Nicholl, 2014) and also a high-level cognitive process. Numerous attempts have been made to understand creativity in various fields of design (Hasirci & Demirkan, 2007). In general, creativity means the process of breaking common rules and beliefs, and creative ideas serve as a background for innovations (Hatchuel et al., 2009; Amabile et al., 1996). Creative thought is obtained through cognitive and sensory methods with practice and interaction (Torrance, 1987). Creative design either introduces some new variables or presents new schemas, which are interacting concepts (Gero, 1996). A creative design can present various hybrid and flexible alternatives that can answer questions in different aspects, while it can find the problems (Shaughnessy,1998). Creativity assessment depends on innovation and utility, which need satisfaction meaning profitability (Ranjan, Siddharth, Chakrabarti, 2018).

Multiple responses are one of the architectural design-specific features. Accurate architectural design requires paying attention simultaneously to various issues, such as efficiency, beauty, strength, audience, and more importantly, the spiritual aspects (Lilian

* *Corresponding author: Tayyah@iaurasht.ac.ir*

et al., 2017). Broadbent and Simon believe that design is an attempt to present and invent solutions before implementing them (Lang, 2011). Architectural design is a multifaceted, complex, and interconnected process that is performed under the control of a creative mind with unity and coordination (Lilian et al., 2017). On the other hand, as a unifying ring, creativity continuously links the stages of design (Tayyah et al., 2021). Creativity in architectural design is accepted as an essential component of the design process (Mahdizadeh Hakak et al., 2015), and the built environment needs creativity to have a better future (Feizi & Alipour, 2017).

Although there is a right understanding of the importance of creativity in architectural design, many obstacles remain. Creativity is one of the most important priorities of individual principles and needs in design, and many contemporary theorists in the field of design emphasize the development of creativity (Hadian & Pourmand, 2014).

What makes the present study important and necessary is that improving the quality of architecture always requires creativity and new solutions, and its assessment depends on knowing the assessment components in the field of architectural creativity. In their study, Guenther et al. scored creativity based on the components of originality or (novelty) of the ideational output, flexibility (i.e., the number of different categories or themes covered by the ideas), and fluency (i.e., the total number of ideas) (Guenther, Eisenbart & Dong, 2021). Studies by theorists in the field of creativity assessment have shown an emphasis on examining the relationship between the creative product and creativity in the design process (Hennessey, 1994; Dorst and Cross, 2001). Since the essential components of creativity include individuals, processes, products, and environments (Rhodes, 1961/1987; Basadur, Pringle, Speranzini, & Bacot, 2000; Murdock & Puccio, 1993), this study examines the process and creative product as the main components. The present study aims to explain the components required to assess the creativity of architecture novices. So, the main question is what the creativity assessment components are in architectural design? To answer this question, the following two secondary questions are raised:

• What components are considered to assess the creativity of architecture novices in the architectural design process?

• What components are considered to assess the creativity of architecture novices in the final design product?

## RESEARCH INNOVATION

Reviewing previous studies and relevant resources shows the attention of professors, researchers, and theoreticians to this issue, as well as the importance of this issue. Table 1 examines the objectives and the relationship between previous research and the topic of this research.

**Table 1.** Research Background Check Table

| | The title of the research | author | The date of the research | Connection with the present study | Research result |
|---|---|---|---|---|---|
| 1 | A spatial design guideline for supporting creativity at architectural firms | Labib et al | 2023 | Examining the effect of spatial design on the users and factors affecting the design regarding the support and enhancement of users' creativity | They introduced factors affecting the design regarding the support and increase user's creativity: layout, the use of plants in specific places, light, color, and furniture |
| 2 | Creativity and successful product concept selection for innovation | Guenther et al | 2021 | How to evaluate and score creativity | scoring creativity based on the components of originality or (novelty), flexibility, and fluency (i.e., the total number of ideas) expressing that a considerable part of innovation and creativity is related to the ability to detect interesting and unusual topics and discussions in the design. |
| 3 | Evaluating Creativity and Success among Architecture Students at the University of Tehran Based on the Four-Quadrant Brain | Khorrami et al | 2022 | Study of the relationship between creativity and academic performance of students | The results indicated that the instructors of design courses mostly emphasize divergent and intuitive thinking in their programs and assessments, but creativity is the result of using both the unconscious |

| | | | | | |
|---|---|---|---|---|---|
| | Dominance Model of Ned Herrmann | | | | mind (intuitive thinking) and the conscious mind (analytical thinking). Creating a successful design process requires the use of implicit knowledge in the left cerebral hemisphere to achieve creativity in the right cerebral hemisphere, and successful design process models are formed as a result of the interaction between the left and right cerebral hemispheres. |
| 4 | Conceptual Model of Design Process in Architectural Education | Torabi | 2014 | Study of the effective functions in the formation of creative ideas and subjective stages of the creativity process (such as vision, preparation, incubation, illumination, and verification) and the objective steps of creativity (such as combination, mutation, analogy, first principle, and emergence). | The results indicated the enhancement of students' creativity due to the change in the goal of the design process. |
| 5 | The Assessment of Creativity: An Investment-Based Approach | Sternberg | 2012 | Investigation and assessment of individual creativity | By stating the investment theory of creativity, he introduced six distinct but related sources, namely intellectual ability, knowledge, styles of thinking, personality, motivation, and the environment. According to this theory, these six components contribute to creativity. |
| 6 | Methods that may stimulate creativity and their use in architectural design education | Kowaltowski et al | 2010 | Presenting and reviewing tools and methods enhancing creativity in architecture | The methods included analogy, attribute listing, brainstorming, mind mapping, and biomimicry. The results indicated that these methods stimulate the creativity process mostly informally, and it is recommended to use methods structurally in the enhancement of creativity. |
| 7 | Creativity in the design process: co-evolution of problem–solution | Dorst and Cross | 2001 | Studying and examining creativity from different aspects, such as creativity and originality, creativity, and definition of the design problem, and modeling of creative design as co-evolution, bridges, frames, defaults, and surprises. | They presented various observations about the nature of design creativity. According to the obtained results, the creative aspect of design can be described by introducing the concepts of default and surprise in the design problem and solution. Surprise is a component keeping the designer from routing behavior. As a result, the surprising parts of a problem or solution cause the appearance of originality and novelty in the design project. |
| 8 | The Consensual Assessment Technique: An Examination of the Relationship Between Ratings of Product and Process Creativity | Hennessey | 1994 | Addressing the factors that judges are responding to when assessing creativity. | The results indicated that the relationship between process creativity, product creativity, and its rating, as well as the age of the creator, are component influencing judges' subjective assessment. |

The studies by theorists in this field show an emphasis on examining the components of creativity assessment. However, in recent research in the field of creativity, the factors effective in "creating, enhancing, and stimulating" creativity have been more addressed.

A small number of previous studies have attempted to provide a more rational method for examining and assessing creativity. However, the review of them shows that only a few limited components have been examined, without determining the effectiveness of each one.

What distinguishes the present study is the separate assessment of creativity in two aspects of the design process and the final design product and also the presentation of detailed components for both steps that have been approved and compiled by architectural experts. According to the results of this study, the components of architecture novice creativity assessment and their effectiveness based on the statistical results of this study are introduced to architecture professors and the community, which can be useful and effective in rating and assessing the creativity level of individuals in architectural design.

## METHODS

In the research structure, the research methodology includes a descriptive-analytic method and a correlation method. Using the descriptive-analytic method, the meanings were analyzed, theoretical foundations were described, data were interpreted, and the correlation method was applied to analyze the correlation between the research variable, considering the research purpose. This method is one of the descriptive, non-experimental methods. In most bivariate correlation research, the measure of distances with the default bivariate normal distribution is used to measure the variables, and the calculated correlation coefficient is the same as Spearman's correlation coefficient. In this study, to determine the extent to which changes in two variables are coordinated, the bivariate correlation method was used. In the correlation method, the Friedman test was applied in the SPSS software to find the relationship between research variables. Two questionnaires were designed through the following steps in this study. In the first step, a questionnaire was designed in the architectural design process and its final product to extract components for assessing the creativity of novices and another questionnaire was prepared for both process and product to assess the effectiveness of the components extracted from the first step. In the first step, the Delphi technique, which has several steps, was used to extract effective components and present them to the professional statistical society. The complementary information proposed by the experts was gathered by using several stages of an open-ended questionnaire based on the fundamental basics extracted from the literature review. Then, each participant received a closed-ended questionnaire based on the summarized key points of the previous steps. In the next step, participants prioritized the dimensions of the topic under discussion, and disagreements between experts were found. In this step, a consensus began to form, and participants' responses were sent to each other. In the next step, they were asked to revise their ideas about the considered topics and express their reasons for disagreeing with the points. Ultimately, the previous steps were repeated, and a closed-ended questionnaire was designed based on which the components of assessing the creativity of novices were extracted by collecting the opinions of professionals and experts. In another closed-ended questionnaire, the effectiveness of the components obtained from the architectural design process and its final product was then judged by the experts and verified and scrutinized within several steps. Finally, the relationship between these variables was assessed based on the objective, analysis, and Spearman's coefficient of correlation between creativity assessment variables. The data analysis tool is SMART-PLS Software. In this research, a combined conversion scheme was used, and Figure 1 shows the research steps in moving between data collection and analysis tools.

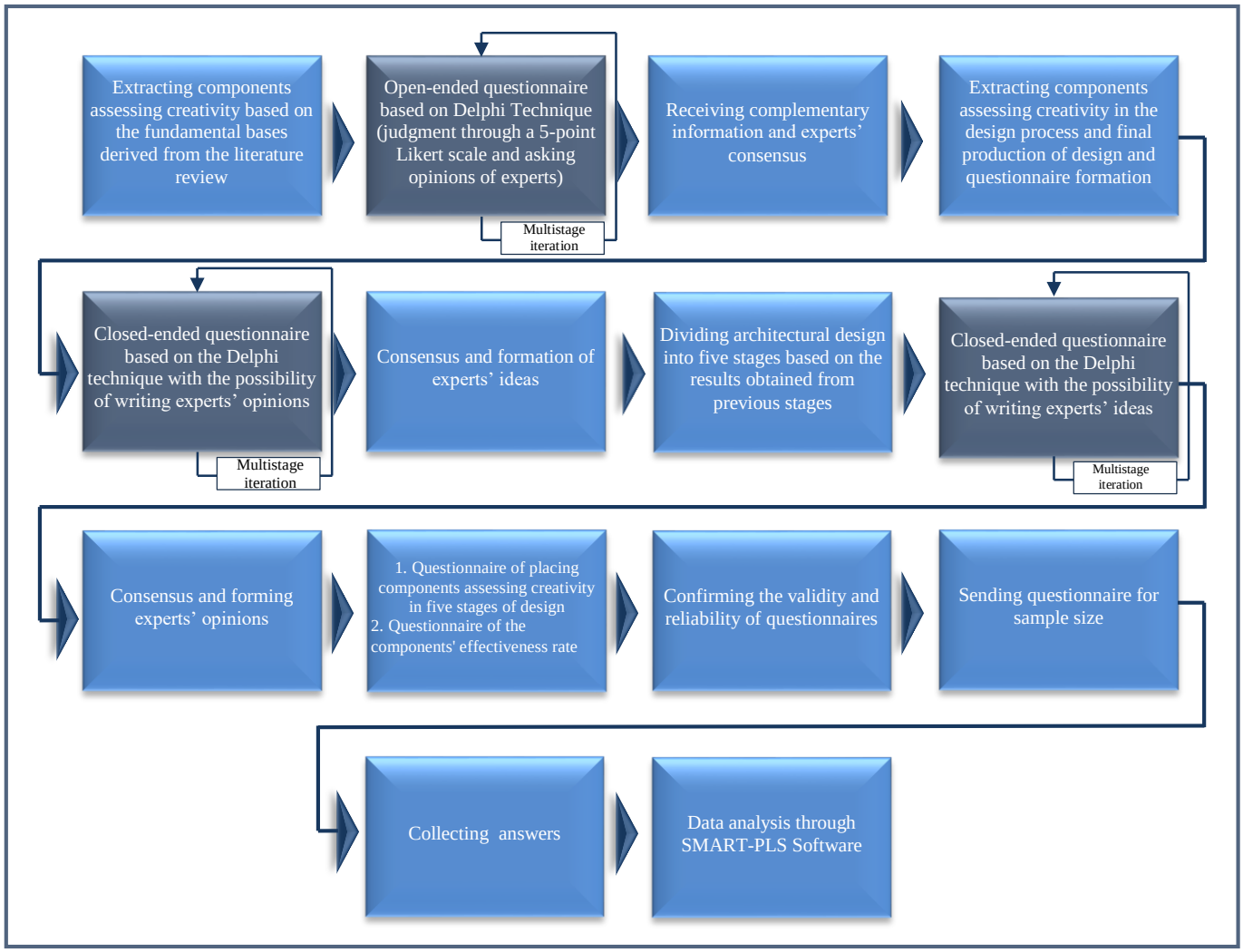


**Fig 1.** Research Process

***Statistical population and sample size***

A statistical population includes a set of individuals and units with at least one common trait. A sample refers to a set of signs selected from a larger part, group, or population. This selection is such that this set of signs has the characteristics of that larger part, group, or population (Khaki, 2012). In the present study, considering the research purpose, the statistical population included experts and faculty members of different universities with relevant specialities and preferably experience in teaching design courses in the field of architecture. Out of 600 experts surveyed, 116 people filled out the questionnaire, and most of them were Iranians. Figures 2, 3, and 4 show the characteristics of the sample size.

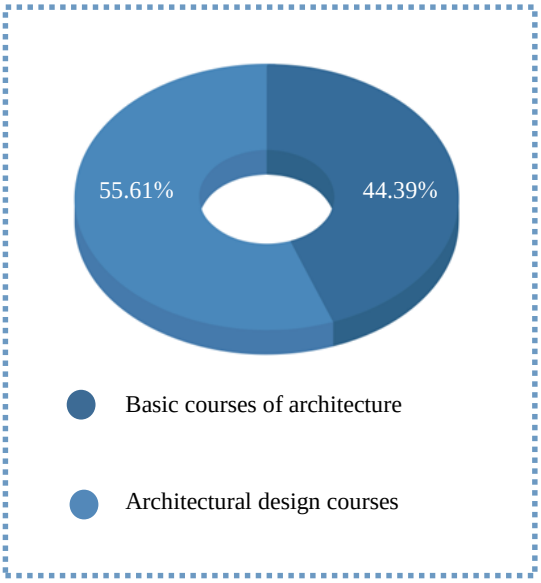


**Fig 2.** The Topics Taught by the Sample Size

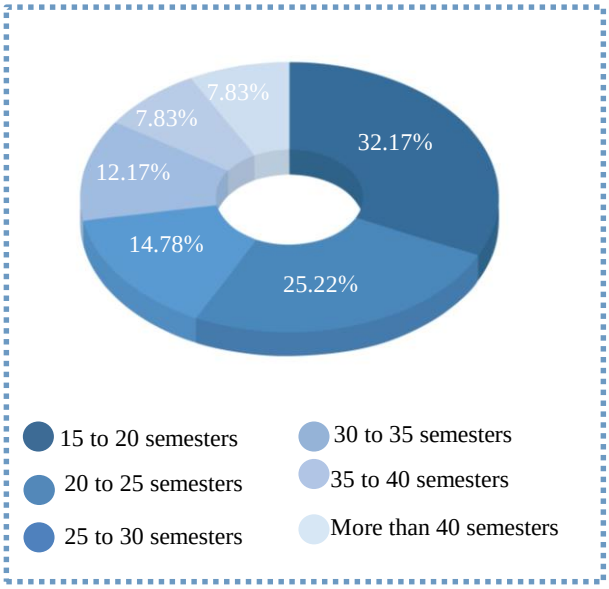


**Fig 3.** The Sample Size's Experience in Teaching Architecture

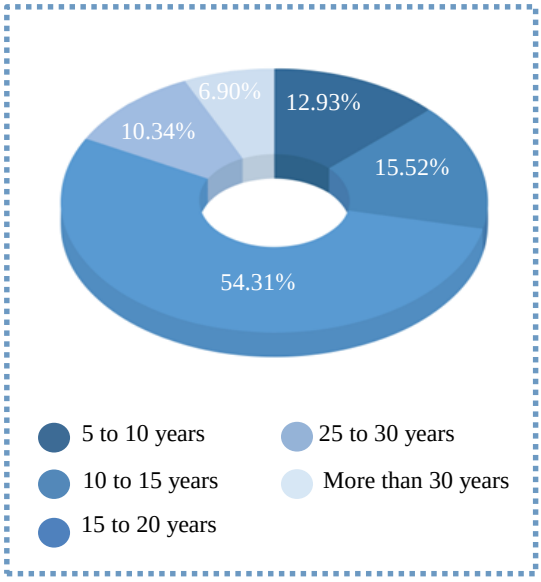


**Fig 4.** The Sample Size's Experience in Architectural Design

***Explanation of the components of assessing creativity in architectural design***

After reviewing theoretical studies and the Delphi open-ended questionnaire, the components of assessing creativity in architectural design were extracted. In this step, to identify and extract the effective components and indicators in measuring the creativity of novices in the design process and their final design products, the opinions of experts were first extracted through several steps of back and forth, collection, revision, and analysis using an open-ended questionnaire. The components are presented separately (during the architectural design process and in the final architectural design product). Column A of Table 2 reports the components of assessing creativity during the architectural design process, and Column A of Table 3 indicates the components of assessing creativity in the final product of architectural design, which is derived from the theoretical studies and research literature, and a Delphi open-ended questionnaire.

***Questionnaire reliability and effective components***

In this step, using the information obtained in the previous step, to examine the effectiveness of the components extracted from the first-step questionnaire, a researcher-made close-ended questionnaire was developed to identify creative architectural designs. To this end, two close-end questionnaires were developed, one of which to determine the effectiveness of the components in assessing the student creativity during the design process (components with an even row number, column C, Table 2), along with the classification of components in the five stages of the design process (cognition and perception, unconscious mind, in-between, consciousness, and evaluation and decision-making) (components with an odd row number, column B, Table 2) and the other, to determine the effectiveness of the components in assessing the creativity of the final design products presented at the end of the semester by novices (Table 3). The professionals and experts were asked to place the selected components in the stages of the design process and to give their opinions on how effective these components are in assessing the creativity of novices during the design process, as well as the creativity of their final designs. In the following, these components, their effectiveness, and classification in the design process are explained.

**Table 2.** Questionnaire on the Effective Components in Assessing the Creativity of Architecture Novices During the Design Process

| Column A | | Column B | | | | | Column C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Design process steps | | | | | Degree of effectiveness | | | | | |
| Effective components in assessing the creativity of architecture novices during the design process | | Recognition and perception | Imagination (unconscious mind) | In-between (the distance between unconsciousness and consciousness | Intellection (consciousness) | Final decision based on individual evaluation | Very high | High | Moderate | Low | Very low | No effect |
| 1-2 | Problem recognition | 95 | 12 | 22 | 23 | 15 | 99 | 8 | 7 | 1 | 1 | - |
| 3-4 | Right understanding and framing of the problem | 72 | 19 | 30 | 40 | 14 | 81 | 11 | 22 | 1 | 1 | - |
| 5-6 | Innovation (uniqueness of ideas) | 16 | 64 | 50 | 26 | 20 | 64 | 11 | 34 | 7 | - | - |
| 7-8 | Design idea flexibility (Generation of multiple responses) | 15 | 35 | 44 | 53 | 29 | 39 | 58 | 12 | 5 | 1 | 1 |
| 9-10 | Immersion in the problem (avoiding imitative superficiality) | 29 | 19 | 45 | 66 | 14 | 44 | 56 | 13 | 2 | 1 | - |

| Column A | | Column B | | | | | Column C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Design process steps | | | | | Degree of effectiveness | | | | | |
| Effective components in assessing the creativity of architecture novices during the design process | | Recognition and perception | Imagination (unconscious mind) | In-between (the distance between unconsciousness and consciousness | Intellection (consciousness) | Final decision based on individual evaluation | Very high | High | Moderate | Low | Very low | No effect |
| 11-12 | Discovering the right and useful source of inspiration | 33 | 35 | 44 | 49 | 8 | 29 | 61 | 19 | 6 | - | 1 |
| 13-14 | Use of metaphor and amphibology | 12 | 54 | 51 | 34 | 10 | 19 | 50 | 34 | 10 | 3 | - |
| 15-16 | Use of contradictions | 13 | 19 | 43 | 70 | 21 | 9 | 33 | 44 | 24 | 3 | 3 |
| 17-18 | Divergent view + convergent composition | 19 | 11 | 41 | 71 | 27 | 23 | 61 | 22 | 5 | 1 | - |
| 19-20 | Having coherent theoretical foundations during the process | 48 | 19 | 37 | 73 | 29 | 54 | 45 | 10 | 6 | 1 | - |
| 21-22 | Attention to primary data (per capita and architectural programming) | 41 | 3 | 13 | 73 | 38 | 39 | 41 | 17 | 15 | 4 | - |
| 23-24 | Attention to social and cultural information | 61 | 9 | 19 | 63 | 35 | 46 | 52 | 12 | 4 | 2 | - |
| 25-26 | Attention to climatic and environmental information | 64 | 4 | 16 | 67 | 33 | 50 | 49 | 9 | 7 | 1 | - |
| 27-28 | Attention to the future | 22 | 11 | 23 | 69 | 44 | 35 | 54 | 19 | 5 | 2 | 1 |
| 29-30 | Optimal use of site potential | 61 | 7 | 19 | 67 | 30 | 56 | 50 | 8 | 2 | - | - |
| 31-32 | Attention to objective facts in the field of energy | 33 | 2 | 8 | 80 | 44 | 20 | 53 | 23 | 18 | 2 | - |
| 33-34 | Feasibility of the idea in terms of buildability | 23 | 8 | 20 | 69 | 56 | 28 | 49 | 22 | 14 | 2 | 1 |
| 35-36 | Feasibility of the idea in terms of compliance with construction standards | 20 | 2 | 11 | 66 | 56 | 25 | 39 | 24 | 21 | 5 | 2 |
| 37-38 | Feasibility of the idea in terms of compliance with urban standards | 27 | 2 | 9 | 65 | 52 | 20 | 43 | 26 | 19 | 7 | 1 |
| 39-40 | Proportionality of appropriate methods and strategies to the purpose (the link between requirements and goal) | 26 | 3 | 23 | 58 | 54 | 26 | 64 | 17 | 5 | 2 | 2 |
| 41-42 | Quality of expression/presentation (appropriate text and speech on the process) | 18 | 6 | 21 | 40 | 71 | 33 | 50 | 21 | 11 | 1 | - |

**Table 3.** Questionnaire on the Effective Components in Assessing the Creativity of the Architecture Novices' Final Design Products (End-of-semester Design)

| Column A | | Column B | | | | | |
|---|---|---|---|---|---|---|---|
| | | Degree of effectiveness | | | | | |
| Effective components in assessing the creativity of the architecture novices' final design products (end-of-semester design) | | Very high | High | Moderate | Low | Very low | No effect |
| 1 | Design construction time (minimum implementation time) | 8 | 13 | 30 | 42 | 14 | 9 |
| 2 | Being economical | 15 | 20 | 39 | 30 | 8 | 4 |
| 3 | Reducing resource consumption in project implementation | 17 | 55 | 21 | 16 | 3 | 4 |
| 4 | The visual connection between the form and the subject of design | 45 | 54 | 14 | 3 | - | - |
| 5 | The Conceptual relationship between the form and the subject of design | 53 | 53 | 8 | 2 | - | - |
| 6 | Favorable quality of each designed space | 45 | 57 | 11 | 3 | - | - |
| 7 | Artistic, metaphorical, and abstract answers to the design problem | 38 | 44 | 24 | 8 | 2 | - |
| 8 | Utility (efficiency) of the design | 41 | 58 | 10 | 6 | 1 | - |
| 9 | Innovativeness of the final product (no imitation of similar previous samples) | 52 | 40 | 15 | 8 | 1 | - |
| 10 | Right imitation of previous samples (use of their desirable features) | 21 | 48 | 33 | 9 | 2 | 3 |
| 11 | Inattention to the style of the day (not following the dominant style) | 19 | 40 | 29 | 18 | 3 | 7 |
| 12 | Responding to all issues raised in architectural design | 47 | 46 | 16 | 5 | 2 | - |
| 13 | Communication with public opinion and belief (fluidity) | 24 | 38 | 28 | 22 | 4 | - |
| 14 | Coordination between the design product and its function | 48 | 54 | 9 | 4 | - | 1 |
| 15 | Use of modern technologies | 33 | 51 | 20 | 8 | 1 | 3 |
| 16 | Providing an appropriate cultural solution (attention to the context of the design and the common culture in the region | 51 | 52 | 9 | 4 | - | - |
| 17 | Providing a suitable climatic solution (attention to the context of the design) | 57 | 46 | 7 | 5 | 1 | - |
| 18 | Use of contradictions to make the design outstanding in its context | 15 | 29 | 45 | 33 | 1 | 3 |
| 19 | Sensory enrichment of the subjects, induced by different spatial stimuli | 29 | 63 | 17 | 6 | - | 1 |
| 20 | Creating diversity and flexibility in created spaces | 37 | 61 | 12 | 6 | - | - |
| 21 | New form + New concept | 40 | 53 | 20 | 2 | 1 | - |
| 22 | New form + new function (balance between form and function and lack of dominance over each other) | 39 | 52 | 21 | 4 | - | - |
| 23 | New function + New concept | 21 | 62 | 18 | 4 | 1 | - |
| 24 | New form + new concept + new function | 37 | 56 | 16 | 7 | - | - |
| 25 | Relationship between the design product and the architectural area programming | 27 | 62 | 30 | 6 | - | - |
| 26 | Being mysterious (as opposed to the explicitness of spaces) - innovativeness of spaces | 15 | 39 | 39 | 17 | 4 | 2 |
| 27 | Using the indigenous patterns | 27 | 44 | 26 | 17 | 1 | 1 |
| 28 | Quality of expression/presentation (appropriate representation of the product) | 24 | 62 | 22 | 7 | 1 | - |
| 29 | Oral presentation and critical reasoning of the designer in describing the creative aspect of the design | 27 | 47 | 35 | 7 | - | - |

In human studies, measuring variables always implies some degree of error. The only scattering value in an ideal study is the existence of different individuals (Szklo & Javier, 2017). Therefore, one of the major challenges of human and social research is to find reliable tools. The reliability of the questionnaire refers to the extent to which a questionnaire produces the same results on repeated trials. To ensure the results obtained from the analysis of the questionnaire data, the reliability of the questionnaire was assessed. The reliability of a measurement tool refers to the extent to which the results obtained by a tool are similar, accurate, and reliable if the characteristic being measured is repeatedly measured under the same conditions by the same measurement tool. In other words, it can be said that the purpose of reliability is to what extent the measurement tool produces the same results under the same conditions. The reliability coefficient can change within a range from zero to one, in full relation to the results obtained in repeated measurements of the population.

### *Assessment of content validity (CVI / CVR) and reliability of the questionnaire*

To assess the content validity, experts' opinions about the coordination between the content of the measurement tool and the research purpose were used. For this purpose, two qualitative and quantitative methods were considered. To examine the content qualitatively, experts were asked to provide the necessary feedback on the tool, according to which the questionnaire was modified. But to examine the content validity quantitatively, two relative coefficients of content validity ratio (CVR) and content validity index (CVI) were used. The CVI was estimated by dividing the sum of the scores for each component ranked as "relevant but in need of modification" and "quite relevant" by the total number of experts. In this step, first, CVI was calculated for each component, and the mean was defined as the total CVI. Since the total CVI was above 0.79, it was confirmed. To estimate the CVR, experts were asked to rank each component by one of the options of "useful but not necessary", "necessary", and "unnecessary", then the options were scored and the final CVR was calculated. In this step, since the number of experts was 116, the minimum value of the CVR must be 0.33 (Hajizadeh & Asghari, 2011). For all components, this coefficient was also confirmed. Next, to calculate the Cronbach's alpha coefficient, first, the standard deviation of the scores of each subset of questions and the standard deviation of the whole set of questions (subsets) were calculated, and then the alpha coefficient of each subset of questions was obtained. In this regard, the results of Cronbach's alpha test in Table 4 indicate that the obtained reliability value is 0.832, which is acceptable because it is above 0.7. Therefore, the questions of the research questionnaire have appropriate and desirable reliability.

**Table 4.** Results of Cronbach's Alpha Test for the Effective Components in Assessing the Creativity of Architecture Novices During the Design Process

| Component | Mean | Standard deviation | Cronbach's alpha |
|---|---|---|---|
| Problem recognition | 4.7586 | .68042 | .835 |
| Right understanding and framing of the problem | 4.47 | .889 | .832 |
| Innovation (uniqueness of ideas) | 4.1466 | 1.04052 | .844 |
| Having coherent theoretical foundations during the process | 4.0862 | .90955 | .834 |
| Optimal use of site potential | 4.2069 | .77479 | .828 |
| Attention to social and cultural information | 3.95 | .873 | .831 |
| Immersion in the problem (avoiding imitative superficiality) | 3.61 | .949 | .836 |
| Discovering the right and useful source of inspiration | 3.10 | 1.066 | .824 |
| Design idea flexibility (Generation of multiple responses) | 3.85 | .816 | .842 |
| Quality of expression/presentation (appropriate text and speech on the process) | 4.2586 | .88584 | .817 |
| Divergent view + convergent composition | 3.8276 | 1.13655 | .817 |
| Attention to climatic and environmental information | 4.17 | .878 | .823 |
| Attention to the future | 4.21 | .890 | .814 |
| Use of metaphor and amphibology (abstract thinking) | 3.96 | .973 | .821 |
| Attention to primary data (per capita and architectural area programming) | 4.3793 | .69351 | .826 |
| Proportionality of appropriate methods and strategies to the purpose (the link between requirements and goal) | 3.61 | 1.002 | .812 |
| Feasibility of the idea in terms of buildability | 3.7241 | 1.06800 | .814 |
| Attention to objective facts in the field of energy | 3.45 | 1.232 | .810 |
| Feasibility of the idea in terms of compliance with urban standards | 3.41 | 1.179 | .808 |
| Use of contradictions | 3.8707 | .98272 | .824 |
| Feasibility of the idea in terms of compliance with construction standards | 3.8879 | .95800 | .830 |
| Total alpha | .832 | | |

In the case of the effective components in assessing the creativity of the design product (end-of-semester design), the results of Cronbach's alpha test in Table 5 indicate that the overall reliability obtained for these components is 0.841, which is acceptable because it is above 0.8.

The results of Spearman's correlation coefficient test (Table 6) indicate that there was a positive and significant relationship between the effective components in assessing the creativity of architecture students during the design process. In other words, significant relationships were observed between the stage of recognition and the stages of imagination (unconscious mind), intellection (consciousness), and final decision based on the individual evaluation, while no significant relationship was observed between it and the stage of in-between (the distance between unconsciousness and consciousness). Moreover, no significant relationship was observed between the stage of imagination and other stages, while significant and positive relationships were observed between the stage of intellection and the stages of recognition and final decision based on the individual evaluation. Regarding the "final decision based on the individual evaluation" stage, significant and positive relationships were observed between it and the stages of "recognition and perception" and "intellection", and it was not significantly related to other stages. No significant and positive relationship was also observed between the "in-between" stage and other stages.

**Table 5.** Results of Cronbach's Alpha Test for the Effective Components in Assessing the Creativity of the Design Product (End-of-semester Design)

| Component | Mean | Standard deviation | Cronbach's alpha |
|---|---|---|---|
| Responding to all issues raised in architectural design | 4.7586 | 0.835 | 0.835 |
| The conceptual relationship between the form and subject of the design | 4.2069 | 0.828 | 0.828 |
| Coordination between the design product and its function | 3.96 | 0.821 | 0.821 |
| Providing an appropriate cultural solution (attention to the context of the design and the common culture in the region | 3.61 | 0.812 | 0.812 |
| Providing a suitable climatic solution (attention to the context of the design) | 3.7241 | 0.814 | 0.814 |
| Favorable quality of each designed space | 3.95 | 0.831 | 0.831 |
| The visual connection between the form and the subject of the design | 4.0862 | 0.834 | 0.834 |
| Innovativeness of the final product (no imitation of similar previous samples) | 3.85 | 0.842 | 0.842 |
| New function + New concept | 4.47 | 0.832 | 0.832 |
| New form + New concept | 3.8879 | 0.830 | 0.830 |
| New form + new function (balance between form and function, and lack of dominance over each other | 4.7586 | 0.835 | 0.835 |
| New form + new concept + new function | 4.1466 | 0.844 | 0.844 |
| Utility (efficiency) of the design | 3.10 | 0.824 | 0.824 |
| Creating diversity and flexibility in created spaces | 3.8707 | 0.824 | 0.824 |
| Relationship between the design product and the architectural area programming) | 4.0862 | 0.834 | 0.834 |
| Sensory enrichment of the subjects, induced by different spatial stimuli | 3.41 | 0.808 | 0.808 |
| Quality of expression/presentation (appropriate writing and appropriate representation of the product | 3.61 | 0.836 | 0.836 |
| Artistic, metaphorical and abstract answers to the design problem | 3.61 | 0.836 | 0.836 |
| Use of modern technologies | 4.3793 | 0.826 | 0.826 |
| Communication with public opinion and belief (fluidity) | 4.21 | 0.814 | 0.814 |
| Using the indigenous patterns | 3.95 | 0.831 | 0.831 |
| Reducing resource consumption in project implementation | 4.1466 | 0.844 | 0.844 |
| Right imitation of previous samples (use of their desirable features) | 4.2586 | 0.817 | 0.817 |
| Being mysterious (as opposed to the explicitness of spaces) - the innovativeness of spaces | 4.2069 | 0.828 | 0.828 |
| Use of contradictions to make the design outstanding in its context | 3.45 | 0.810 | 0.810 |
| inattention to the style of the day (not following the dominant style) | 3.8276 | 0.817 | 0.817 |
| Being economical | 4.47 | 0.832 | 0.832 |
| attention to the design and construction time (minimum implementation time) | 4.17 | 0.823 | 0.823 |
| Oral presentation and critical reasoning of the designer in describing the creative aspect of the design | 3.10 | 0.824 | 0.824 |
| Total alpha | 0.841 | | |

**Table 6.** Results of Spearman's Correlation Coefficient Test for Finding the Relationship Between the Effective Components in Assessing the Creativity of Architecture Novices During the Design Process

| Design process steps | Degree of correlation | Recognition and perception | Imagination (unconscious mind) | Intellection consciousness) | Final decision based on individual evaluation | In-between (distance between consciousness and unconsciousness) |
|---|---|---|---|---|---|---|
| Recognition and perception | Correlation coefficient | 1 | .287** | .294** | .427** | .269** |
| | Level of significance | | .002 | .001 | .000 | .003 |
| | N | 116 | 116 | 116 | 116 | 116 |
| Imagination (unconscious mind) | Correlation coefficient | .287** | 1 | .435** | .467** | .187* |
| | Level of significance | .002 | | .000 | .000 | .044 |
| | N | 116 | 116 | 116 | 116 | 116 |
| In-between (distance between consciousness and unconsciousness) | Correlation coefficient | .269** | .187* | .417** | .173 | 1 |
| | Level of significance | .003 | .044 | .000 | .063 | |
| | N | 116 | 116 | 116 | 116 | 116 |
| Intellection consciousness)( | Correlation coefficient | .294** | .435** | 1 | .279** | .417** |
| | Level of significance | .001 | .000 | | .002 | .000 |
| | N | 116 | 116 | 116 | 116 | 116 |
| Final decision based on individual evaluation | Correlation coefficient | .427** | .467** | .279** | 1 | .173 |
| | Level of significance | .000 | .000 | .002 | | .063 |
| | N | 116 | 116 | 116 | 116 | 116 |

## DATA ANALYSIS

### *Correlation method - finding the relationship between variables*

In this step, using appropriate descriptive and inferential statistics, the components of creativity assessment in architectural design were tested according to the data collected by the Delphi questionnaire. To analyze and interpret the data, it is required to convert them into valuable information using statistical tests to achieve the desired results. In this step, using statistical tests, the collected data were analyzed. The tests used in this study were Spearman's correlation coefficient and the regression test, the results of which were examined.

In statistics, various indicators are used to show the dependence between two or more variables. One of the most widely used indicators is the correlation coefficients, which show the dependence in a standardized way. Correlation coefficients usually range from -1 to 1. The closer the absolute value of these coefficients is to 1, the greater the dependence between the variables. In the present study, since the data distribution is non-normal, Spearman's correlation coefficient was used due to its favorable structure for ranked data.

Therefore, in this step, first the descriptive statistics and then the results of the statistical tests were checked with the help of parametric statistics. Table 7 shows the results of the Friedman test.

The results of Friedman's test show that among the components effective in assessing the creativity of architecture novices during the design process, the most and the least important components are the components of "problem recognition" and "discovering the right and useful source of inspiration" (Evidence-based design), respectively, from the experts' view. This is also statistically confirmed since the level of significance obtained is less than 0.05.

The results of Friedman's test in Table 8 indicate that among the components effective in assessing the creativity of the final design product, the most and the least important components are the components of "the conceptual relationship between the design form and the design subject" and "attention to the design construction time (minimum implementation time)", respectively, from the experts' view. This is also statistically confirmed since the level of significance obtained is less than 0.05.

**Table 7.** Results of Friedman Test for the Prioritization of Effective Components in Assessing the Creativity of Architecture Novices During the Design Process

| Component | N | Percent | Mean | Sd. | Error |
|---|---|---|---|---|---|
| Problem recognition | 116 | 95.17 | 4.7586 | .68042 | .06318 |
| Right understanding and framing of the problem | 116 | 89.40 | 4.47 | .889 | .083 |
| Attention to primary data (per capita and physical program) | 116 | 87.59 | 4.3793 | .69351 | .06439 |
| Quality of expression/presentation (appropriate representation of the product) | 116 | 85.17 | 4.2586 | .88584 | .08225 |
| Considering the future | 116 | 84.20 | 4.21 | .890 | .083 |
| Optimal use of site potential | 116 | 84.14 | 4.2069 | .77479 | .07194 |
| Attention to climatic and environmental information | 116 | 83.40 | 4.17 | .878 | .081 |
| Innovation (uniqueness of ideas) | 116 | 82.93 | 4.1466 | 1.04052 | .09661 |
| Having coherent theoretical foundations during the process | 116 | 81.72 | 4.0862 | .90955 | .08445 |
| Use of metaphor and amphibology (abstract thinking) | 116 | 79.20 | 3.96 | .973 | .090 |
| Attention to social and cultural information | 116 | 79.00 | 3.95 | .873 | .081 |
| Feasibility of the idea in terms of compliance with construction standards | 116 | 77.76 | 3.8879 | .95800 | .08895 |
| Use of contradictions | 116 | 77.41 | 3.8707 | .98272 | .09124 |
| Design idea flexibility (Generation of multiple responses) | 116 | 77.00 | 3.85 | .816 | .076 |
| Divergent view + convergent composition | 116 | 76.55 | 3.8276 | 1.13655 | .10553 |
| Feasibility of the idea in terms of buildability | 116 | 74.48 | 3.7241 | 1.06800 | .09916 |
| Immersion in the problem (avoiding imitative superficiality) | 116 | 72.20 | 3.61 | .949 | .088 |
| Proportionality of appropriate methods and strategies to the purpose (the link between requirements and goal) | 116 | 72.20 | 3.61 | 1.002 | .093 |
| Attention to objective facts in the field of energy | 116 | 69.00 | 3.45 | 1.232 | .114 |
| Feasibility of the idea in terms of compliance with urban standards | 116 | 68.20 | 3.41 | 1.179 | .110 |
| Discovering the right and useful source of inspiration | 116 | 62.00 | 3.10 | 1.066 | .099 |
| Statistical result | * Chi-squre =434.45 df=20 sig=0/000 | | | | |

### *Structural Equation Modeling*

Structural equation modeling is one of the statistical modeling techniques. This is a statistical modeling technique that includes other techniques such as multivariate regression, factor analysis, and path analysis, and its main focus is on latent variables that are defined by measurable indices and observed variables. Using this method allows for the extraction of the cause-and-effect relationships between variables that are not directly observable, considering the errors, and to analyze the correlation between a variable and the effect of each variable on the other. For this reason, structural equation modeling is also known as the analysis of latent variables or causal modeling (Tayyah, 2020). This type of modeling is a path analysis providing parametric estimations of direct relationships between variables. In this method, like regression, the relationships between independent and dependent variables are quantified. Of course, unlike regression parameters that show empirical correlations, structural parameters represent causal correlations. In structural modeling, the process of a causal hierarchy is first introduced in which some variables may be the probable cause of other variables, but cannot be definitively caused by them (Henseler et al., 2009).

In this research, to analyze the data and test the research hypotheses, the partial least squares technique was used. The partial least squares method, also referred to as PLSR (Partial Least Squares Regression) in the regression modeling discussion, is one of the multivariate statistical methods by which one or more response variables can be modeled simultaneously for several explanatory variables, despite some limitations such as the unknown distribution of response variables, small number of observations or major autocorrelation between explanatory variables (Kalantari, 2013). The partial least squares technique, like all structural equation modeling methods, contains a structural component that reflects the relationships between the latent variables and a measurement component that describes the relationship between the latent variables and their components. The third component of this technique is weight relations, which are used for factor estimation of latent variables. Mainly, the PLS method aims to calculate the factor loadings of the components

of a latent variable using the weight relations and based on the average weights of its components to apply these loads to estimate the parameters for structural relationships in a set of regression equations (Asheghi Oskooei, 2011).

The PLS technique determines the coefficients in such a way that the resulting model has the greatest power of interpretation and explanation, meaning that the model can predict the final dependent variable with the highest accuracy. In addition, the PLS technique estimates all the relationships in the model, i.e., the interaction between the latent variables, as well as the weight of all measurable indicators related to each of the latent variables (coefficients outside the measurement model) (Danaei Fard et al., 2013). PLS is a statistical method used to analyze the latent variables of structural models. Unlike methods such as LISREL, the PLS technique aims to obtain latent variables to predict targets using measurable indicators.

**Table 8.** Results of the Friedman Test for the Prioritization of Effective Components in Assessing the Creativity of the Final Design Product (End-of-semester Design)

| Component | N | Percent | Mean | Sd. | Error |
|---|---|---|---|---|---|
| Conceptual relationship between the form and the subject of the design | 116 | 87.07 | 4.3534 | 0.68847 | 0.06392 |
| Providing a suitable climatic solution (attention to the context of the design) | 116 | 86.55 | 4.3276 | 0.84211 | 0.07819 |
| Providing an appropriate cultural solution (attention to the context of the design and the common culture in the region | 116 | 86.03 | 4.3017 | 0.76009 | 0.07057 |
| Favorable quality of each designed space | 116 | 85.00 | 4.2500 | 0.73277 | 0.06804 |
| Coordination between the design product and its function | 116 | 84.83 | 4.2414 | 0.85079 | 0.07899 |
| Visual connection between the form and the subject of the design | 116 | 84.48 | 4.2241 | 0.74701 | 0.06936 |
| Innovativeness of the final product (no imitation of similar previous samples) | 116 | 82.93 | 4.1466 | 0.96237 | 0.08935 |
| Utility (efficiency) of the design | 116 | 82.93 | 4.1466 | 0.84703 | 0.07865 |
| Responding to all issues raised in architectural design | 116 | 82.59 | 4.1293 | 0.92811 | 0.08617 |
| New form + New concept | 116 | 82.07 | 4.1034 | 0.82756 | 0.07684 |
| Creating diversity and flexibility in created spaces | 116 | 82.07 | 4.1034 | 0.79541 | 0.07385 |
| New form + new function (balance between form and function and lack of dominance over each other | 116 | 81.55 | 4.0776 | 0.81455 | 0.07563 |
| New form + new concept + new function | 116 | 81.03 | 4.0517 | 0.84282 | 0.07825 |
| New function + New concept | 116 | 80.17 | 4.0086 | 0.80753 | 0.07498 |
| Diversity in the sensory enrichment of the audience | 116 | 79.14 | 3.9569 | 0.86870 | 0.08066 |
| Relationship between the design product and the physical program | 116 | 78.96 | 3.9478 | 0.79299 | 0.07395 |
| Artistic, metaphorical and abstract answer to the design problem | 116 | 78.79 | 3.9397 | 0.98058 | 0.09104 |
| Quality of expression/presentation (appropriate presentation of the product) | 116 | 77.41 | 3.8707 | 0.83957 | 0.07795 |
| Use of modern technologies | 116 | 77.07 | 3.8534 | 1.09746 | 0.10190 |
| Oral presentation and critical reasoning of the designer in describing the creative aspect of the design | 116 | 76.38 | 3.8190 | 0.86073 | 0.07992 |
| Using the original indigenous patterns | 116 | 73.10 | 3.6552 | 1.07221 | 0.09955 |
| Right imitation of previous samples (use of their desirable features) | 116 | 71.72 | 3.5862 | 1.08803 | 0.10102 |
| Communication with public opinion and belief (fluidity) | 116 | 69.48 | 3.4741 | 1.12258 | 0.10423 |
| Reducing resource consumption in project implementation | 116 | 69.31 | 3.4655 | 1.18271 | 0.10981 |
| Being mysterious (as opposed to the explicitness of spaces) - innovativeness of spaces | 116 | 66.38 | 3.3190 | 1.09226 | 0.10141 |
| Inattention to the style of the day (not following the dominant style) | 116 | 65.34 | 3.2672 | 1.32112 | 0.12266 |
| Use of contradictions to make the design outstanding in its context | 116 | 64.14 | 3.2069 | 1.09161 | 0.10135 |
| Being economic | 116 | 58.62 | 2.9310 | 1.24219 | 0.11533 |
| Attention to the design construction time (minimum implementation time) | 116 | 48.10 | 2.4052 | 1.25787 | 0.11679 |
| Statistical result | Value=1249.58 | | df=28 | sig= 0/00000 | |

***Criteria for Testing the PLS Model***

In structural equation modeling, the overall PLS model validation index is called GOF (Goodness of fit), which was introduced by Tenenhaus et al. (2004). In other words, the GOF index is used to validate the PLS model. This index is a value between zero and one. The closer it is to one, the higher the validity and quality of the model. This index considers both measurement and structural models and is used as a measure for evaluating the overall performance of the model. It is calculated as follows:

GOF = √average (Communality) × average (R2)
GOF =√communality.
R2 =0.403
Communality= 0.524
R2= 0.310

Henseler et al. (2009) defined the three values of 0.15, 0.2, and 0.35 as low, moderate, and strong predictive power, respectively. In this study, according to the value obtained from the above formula, the model fit was determined to be strong.

Regarding factor loadings, it is shown that the larger (and the closer to one) the factor loading, the better the observed variable (question) can explain the latent variable. If the factor loading is less than 0.3, the weak relation is considered and it is ignored. A factor loading between 0.3 and 0.6 is acceptable, and a factor loading above 0.6 is very desirable. The results of factor analysis according to the graphic model in Figures 5 and 6 show that the obtained values are above 0.3. Therefore, all the indicators in the creativity assessment models (during the design process and in the final product) are confirmed.

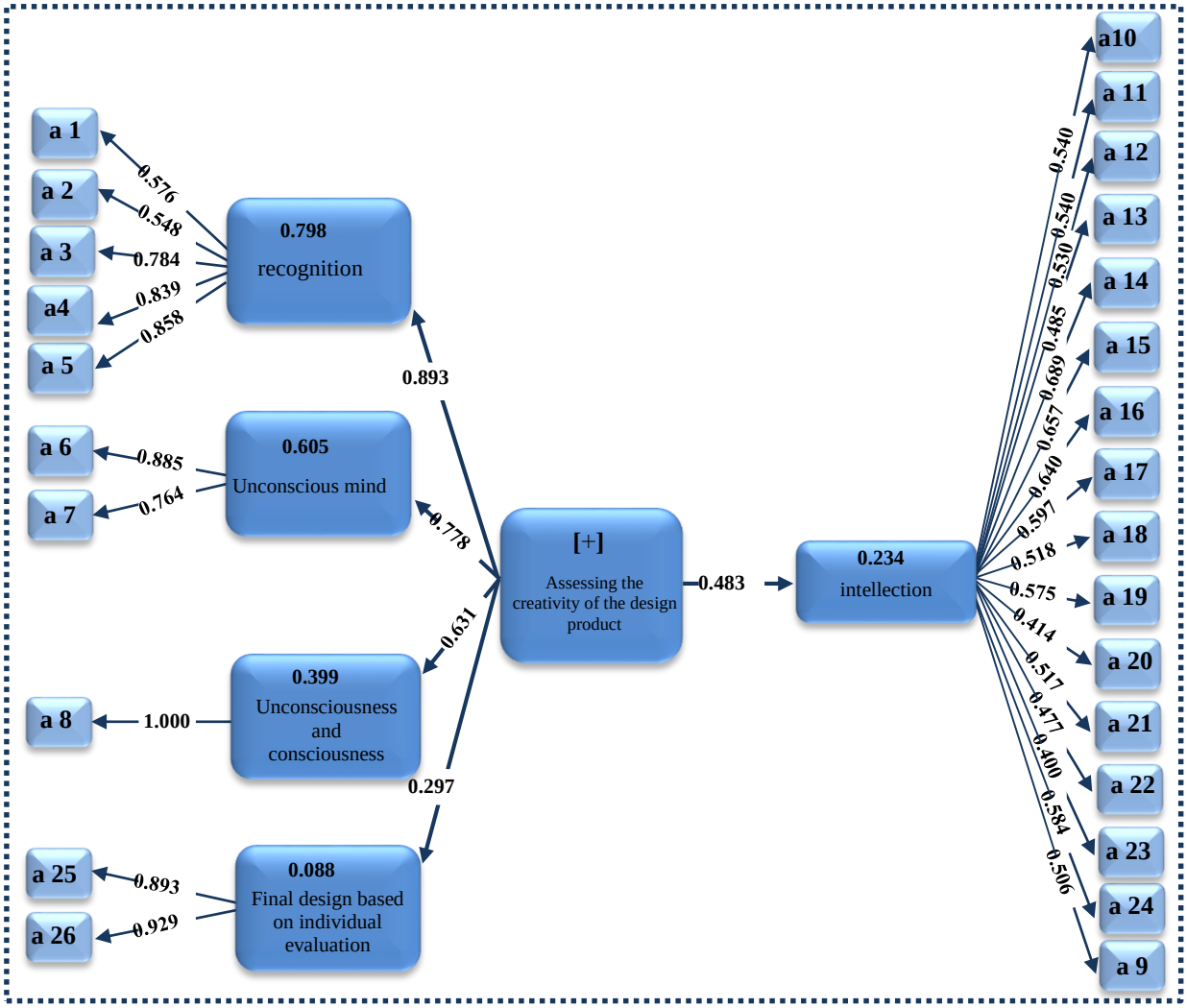


**Fig 5.** Graphic Model for the Creativity of Novices during the Design Process (Based on Standardized Coefficients) Related to Table 2

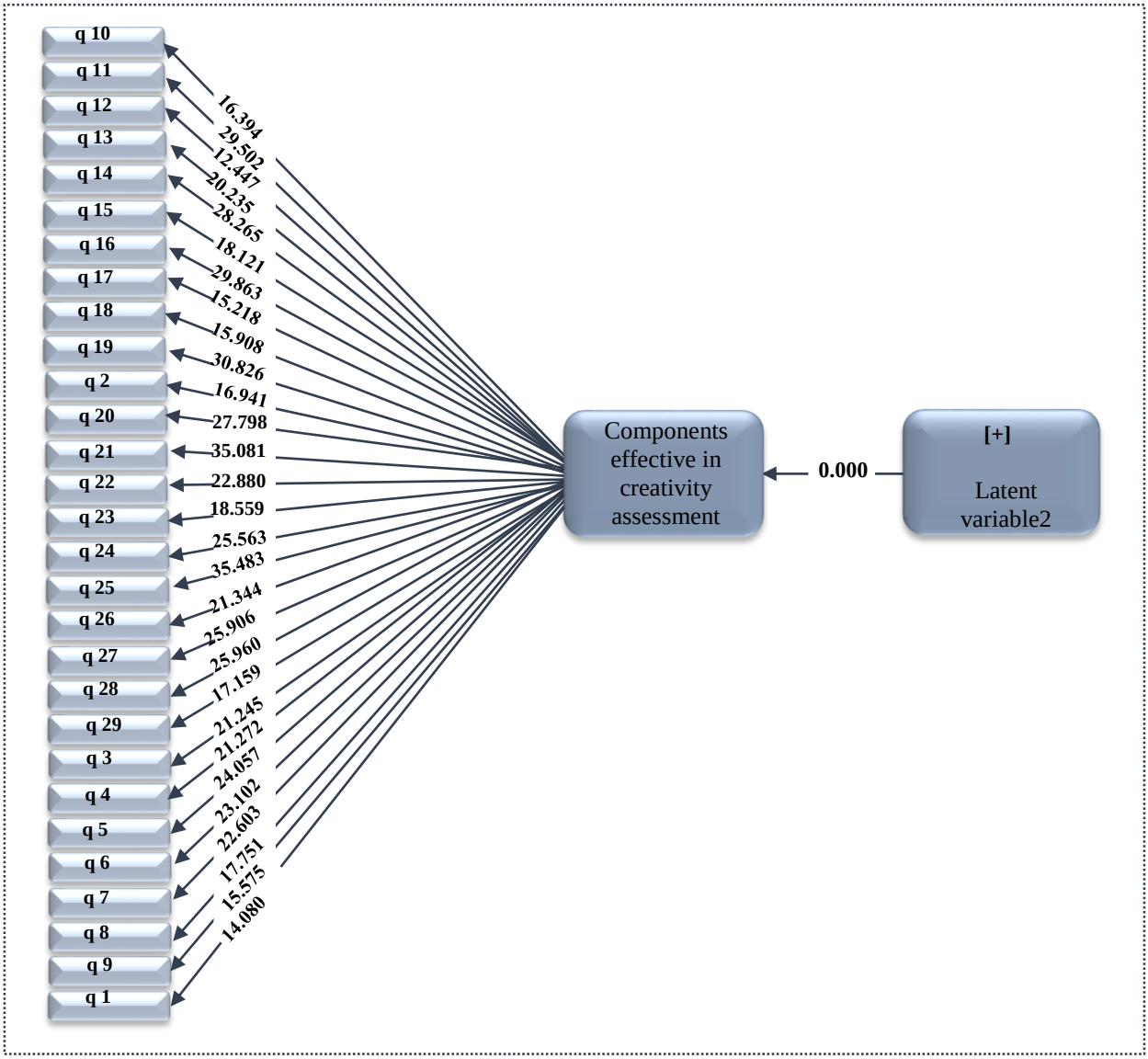


**Fig 6.** Graphic Model for the Creativity of the Final Design Product (Based on Standardized Coefficients) Related to Table 3

## DISCUSSION OF RESULTS

All factor loadings were estimated to be greater than 0.3, indicating the acceptable reliability of the model. Factor loading indicates the correlation between each observed variable (questionnaire question) and the latent variable. The factor loading or lambda is a correlation coefficient between latent and observed variables in a measurement model. This coefficient determines the extent to which the latent variable explains the variance of the observed variables. It must be statistically significant since it is a correlation coefficient. It is considered significant if the T-value (path coefficient) is greater than 1.96, indicating that the relationship between each question and the intended variable is significant. If the T-value of all questions is greater than 1.96, the relationship between the questions and the intended variable is significant and the questions can explain the variable well. The significance of the factor loading was examined with T-value and P-value statistics. There is a very small probability that the T-value (either in the positive or negative direction) will become large, meaning that the probability of such a situation naturally decreases as the distance from zero in both the positive and negative directions becomes greater. According to the graphic models presented in Figures 7 and 8, all the obtained values are greater than 1.96, so all the model indices are confirmed.

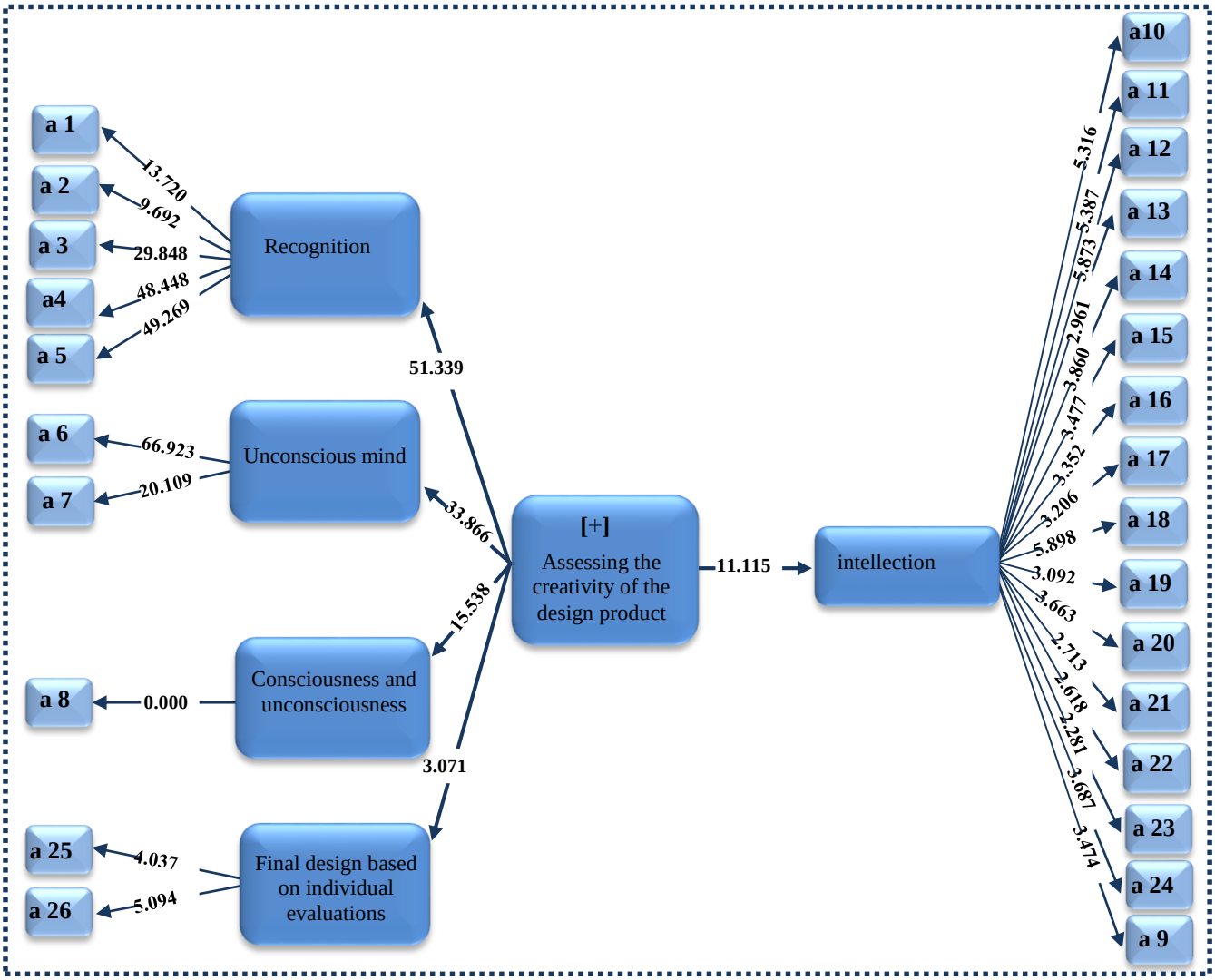


**Fig 7.** Graphic Model for the Creativity of Novices during the Design Process (Based on Significance Coefficients)

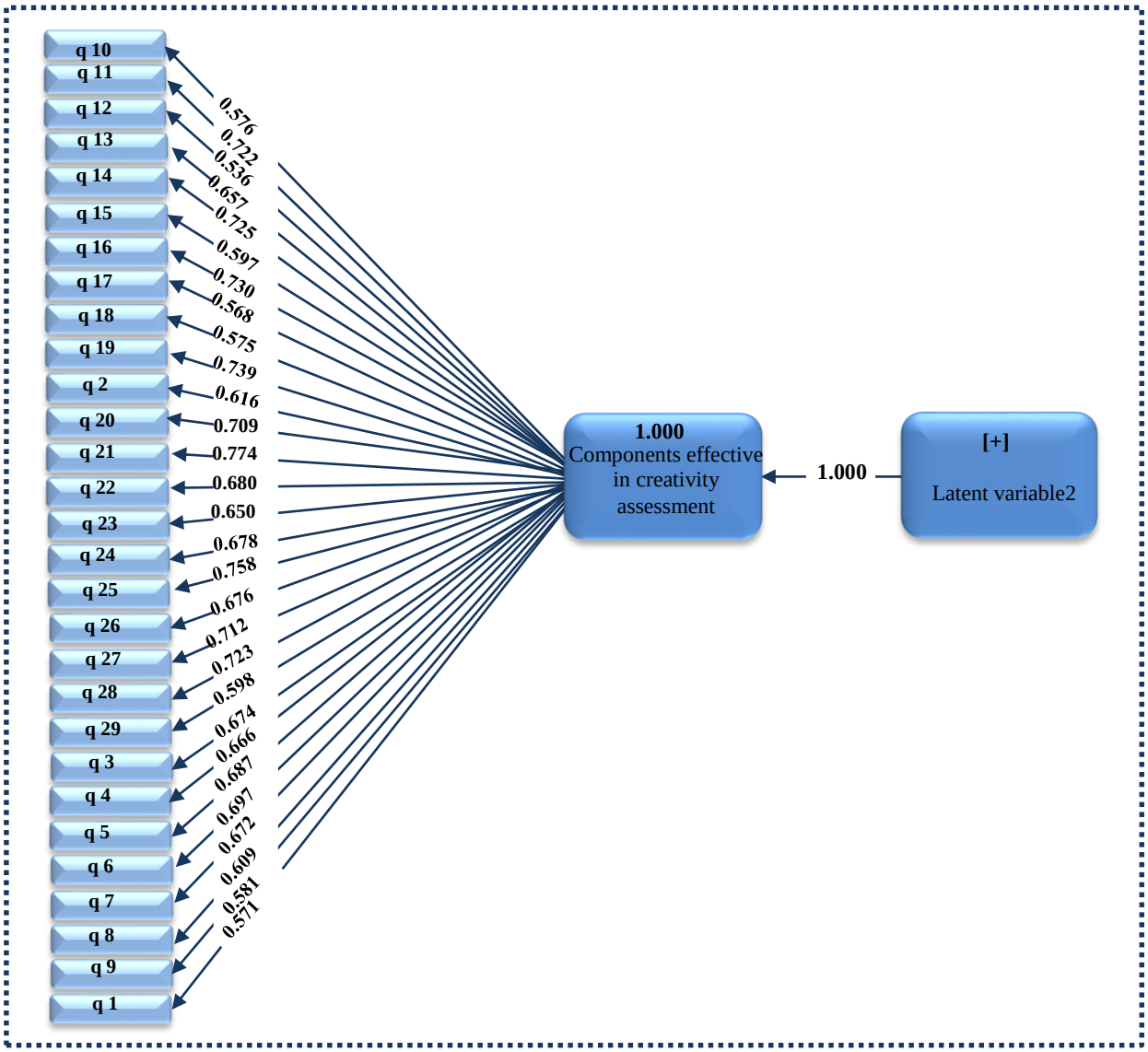


**Fig 8.** Graphic Model for the Creativity of the Design Product (Based on the Significance Coefficient

The above figures show graphic models in a significant state. As seen in these figures, all the coefficients obtained from the items are significant. The T-values greater than 1.96 or less than -1.96 indicate the significance of relationships at the error level of 0.05. In the present study, all the T-values obtained are greater than 1.96, so the validity of all the obtained indices is confirmed.

The second goodness of fit index is the cross-validated redundancy (Q2). This statistic, introduced by Stone and Geisser, determines the predictive relevance of the model or the predictive relevance of the endogenous constructs. Those models with an acceptable structural fit should be able to predict the indicators of the endogenous constructs. If in a model, the relationships between constructs are properly defined, the constructs will be able to have a sufficient impact on each other's indicators and thus the hypotheses are correctly confirmed. A positive Q2 value indicates that the model has good predictive relevance (Henseler et al., 2009).

The value of Q2 was calculated for all endogenous constructs of the model. Q2 values above zero indicate that the indices are well reconstructed and the model can predict. In other words, if all the values obtained for the CV Red index (cross-validated redundancy) are positive, it can be said that the structural model is of good quality. If the value of Q2 is zero or less than zero for an endogenous construct, it indicates that the relationship between it and the other constructs of the model is not well explained.

As seen in the graphic models presented in Figures 9 and 10, all the endogenous research variables obtained positive Q2 values, indicating the model's high ability to predict. Negative Q2 values represent a very poor estimate of the hidden variable. This result indicates that the variables are well reconstructed and can be predicted.

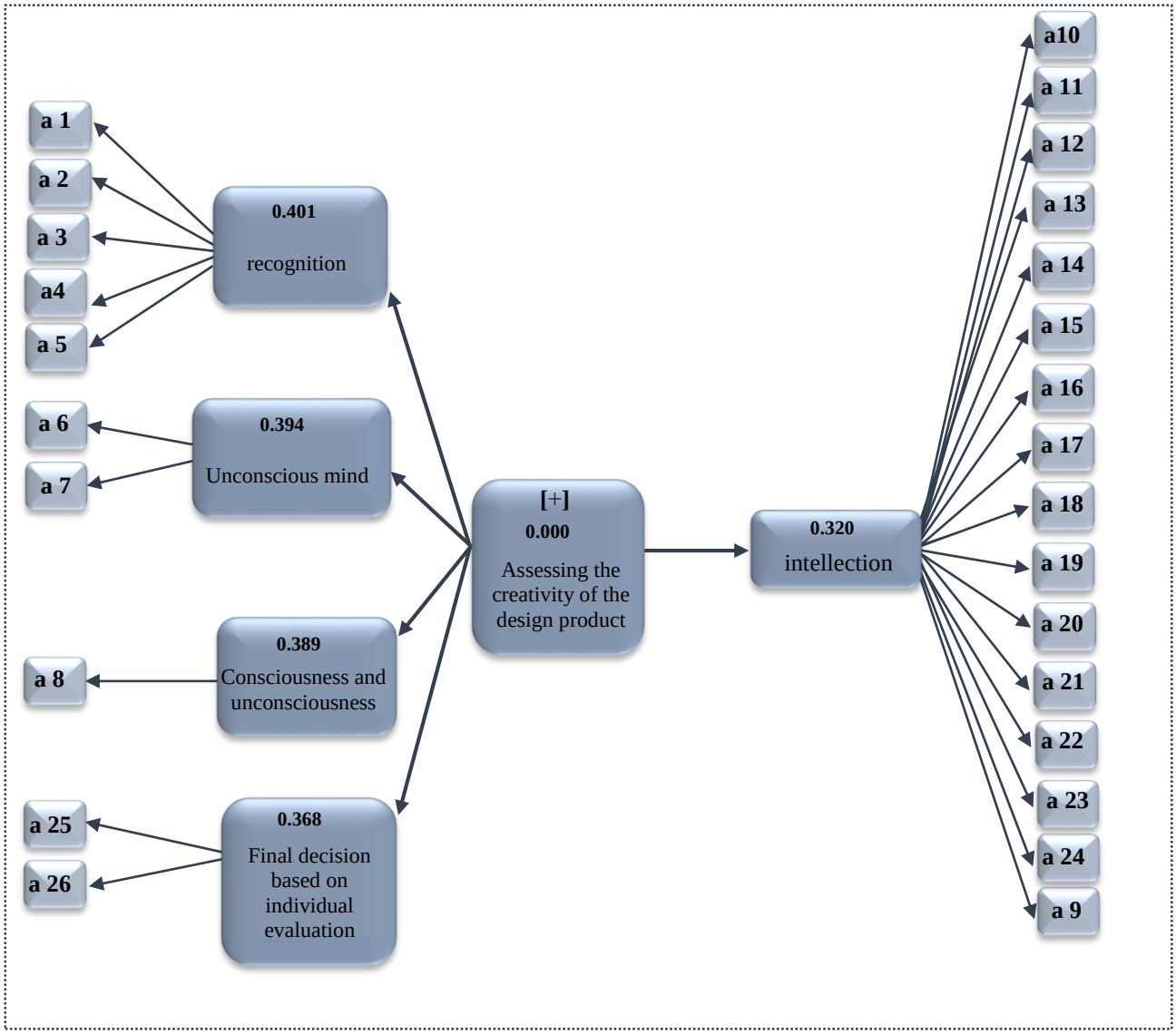


**Fig 9.** Graphic Model for Assessing the Creativity of Novices during the Design Process (Based on CV Red Coefficients)

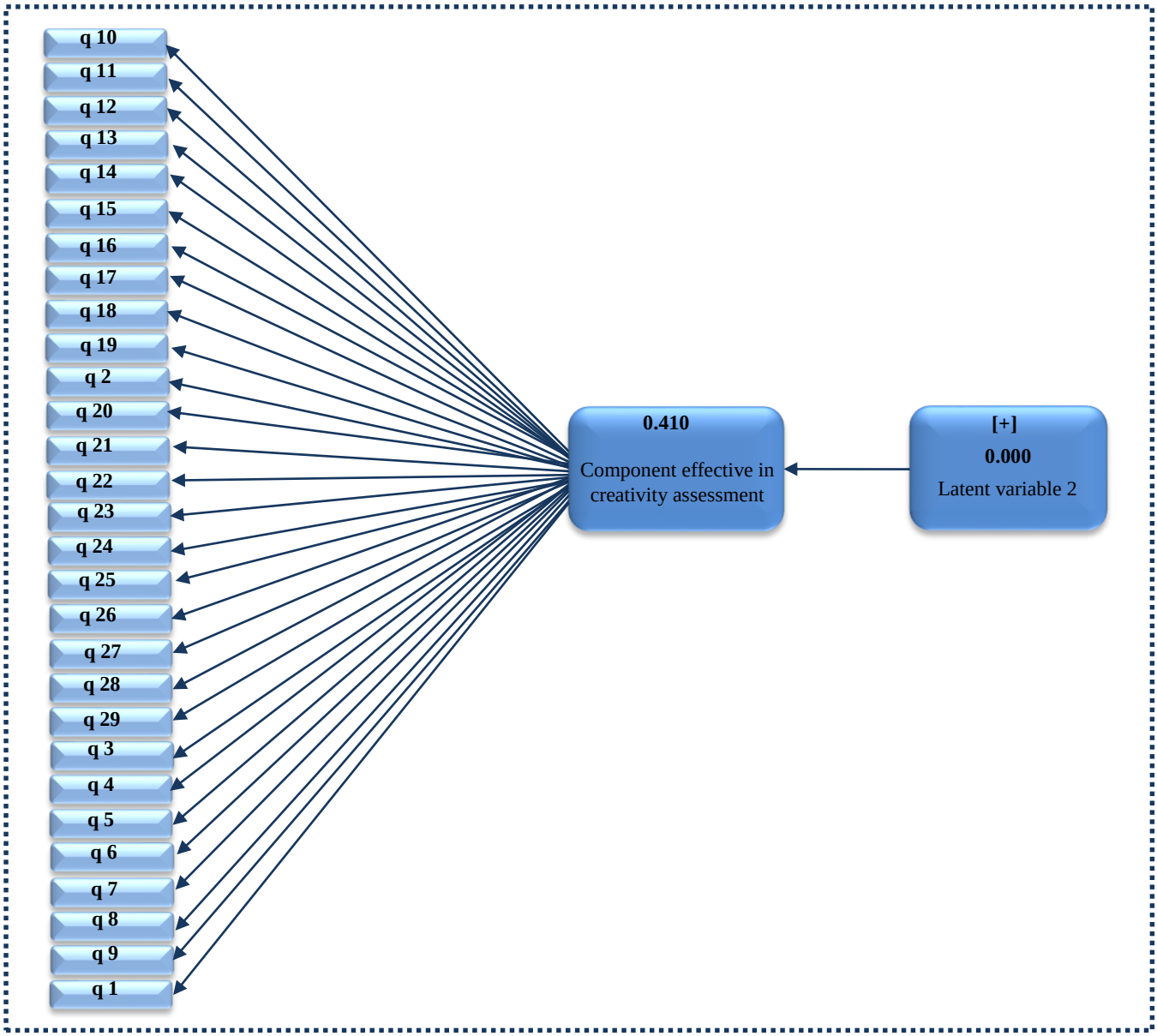


**Fig 10.** Graphic Model for Assessing the Creativity of the Design Product (Based on CV Red Coefficients)

***Confirmatory factor analysis of the effective components in assessing the creativity of novices during the design process***

In this study, to evaluate the significance of the whole questionnaire, confirmatory factor analysis was used. In confirmatory factor analysis, the values of factor loadings are shown according to beta weights ($P < 0.05$). For each factor analysis model, a graph with standardized fitted factor loadings (standardized regression coefficients) and a graph with t-statistic values were plotted. Table 9 shows the measurement model of the first questionnaire in the standard estimation mode. In the standard estimation mode, factor loadings show the extent to which each of the variables or items explains the variance of the scores of the variable or the main factor. In other words, the factor loading indicates the correlation between each observed variable (question) and the latent variable (factors). The results of confirmatory factor analysis show that those questions with a factor loading of less than 0.3 and a t-value of greater than 0.05 are removed from the model, but other indices are confirmed because their factor loadings are greater than 0.3 and their t-values are above 1.96. In the present study, all questions have been confirmed (Figure 5).

**Table 9.** Results of Confirmatory Factor Analysis of Effective Components in Assessing the Creativity of Novices during the Design Process by Standardized Coefficients and Significance Coefficients

| Components | Standardized coefficient | Significance coefficient |
|---|---|---|
| Problem recognition | 0.561 | 5.62 |
| Right understanding and framing of the problem | 0.577 | 2.53 |
| Innovation (uniqueness of ideas) | 0.555 | 5.49 |
| Having coherent theoretical foundations during the process | 0.582 | 2.45 |
| Optimal use of site potential | 0.505 | 2.84 |
| Attention to social and cultural information | 0.513 | 2.51 |
| Immersion in the problem (avoiding imitative superficiality) | 0.425 | 4.01 |
| Discovering the right and useful source of inspiration | 0.548 | 5.85 |
| Design idea flexibility (Generation of multiple responses) | 0.548 | 5.45 |
| Quality of expression/presentation (appropriate text and speech on the process) | 0.682 | 10.93 |
| Divergent view + convergent composition | 0.686 | 11.63 |
| Attention to climatic and environmental information | 0.589 | 6.65 |
| Attention to the future | 0.800 | 16.64 |
| Use of metaphor and amphibology | 0.583 | 6.44 |
| Attention to primary data (per capita and architectural programming) | 0.475 | 4.45 |
| Proportionality of appropriate methods and strategies to the purpose (the link between requirements and goal) | 0.760 | 15.53 |
| Feasibility of the idea in terms of buildability | 0.721 | 12.70 |
| Attention to objective facts in the field of energy | 0.802 | 20.23 |
| Feasibility of the idea in terms of compliance with urban standards | 0.835 | 27.55 |
| Use of contradictions | 0.528 | 5.23 |
| Feasibility of the idea in terms of compliance with construction standards | 0.522 | 3.09 |

**Table 10.** Placement of Creativity Measurement Components in the Design Process, Extracted from the Questionnaire

| Design process steps | Components | The vote percentage |
|---|---|---|
| Recognition | Problem recognition | 81.90 |
| | Right understanding and framing of the problem | 62.07 |
| | Optimal use of site potential | 52.92 |
| | Attention to social and cultural information | 52.92 |
| | Attention to climatic and environmental information | 55.17 |
| Unconscious mind | Innovation (uniqueness of ideas) | 55.17 |
| | Use of metaphor and amphibology | 46.55 |
| Consciousness and unconsciousness | Use of metaphor and amphibology | 43.97 |
| Intellection | Having coherent theoretical foundations during the process | 62.93 |
| | Immersion in the problem (avoiding imitative superficiality) | 56.90 |
| | Discovering the right and useful source of inspiration | 42.24 |
| | Design idea flexibility (Generation of multiple responses) | 45.69 |
| | Optimal use of site potential | 55.76 |
| | Attention to social and cultural information | 54.31 |
| | Divergent view + convergent composition | 61.21 |
| | Attention to climatic and environmental information | 57.76 |
| | Attention to the future | 59.48 |
| | Attention to primary data (per capita and architectural programming) | 62.93 |
| | Proportionality of appropriate methods and strategies to the purpose (the link between requirements and goal) | 50 |
| | Feasibility of the idea in terms of buildability | 59.48 |
| | Attention to objective facts in the field of energy | 68.97 |
| | Feasibility of the idea in terms of compliance with urban standards | 56.03 |
| | Use of contradictions | 60.34 |
| | Feasibility of the idea in terms of compliance with construction standards | 56.90 |
| Final decision based on individual evaluation | Quality of expression/presentation (appropriate text and speech on the process) | 61.21 |
| | Proportionality of appropriate methods and strategies to the purpose (the link between requirements and goal) | 46.55 |

According to Table 10, the results reveal that the components of "optimal use of site potentials", "attention to social and cultural information", and "attention to climatic and environmental information" belong more to the "intelligence" stage in the design process. However, considering the close vote percentages, these components can also be placed in the "cognition and perception" stage.

Also, the "Using metaphors and amphibology (abstract thinking)" component belongs more to the "unconscious mind" stage. However, considering the close vote percentages, it can also be placed in the "in-between (a distance between unconsciousness and consciousness)" stage.

Also, the "proportionality of appropriate methods and strategies to the purpose (a link between requirements and goal)" component belongs more to the "intellection" stage in the design process. However, considering the close vote percentages, it can also be placed in the "final decision based on individual evaluation" stage.

### *Confirmatory factor analysis of the effective components in assessing the creativity of the final design product*

Table 11 presents the results of confirmatory factor analysis of the components affecting creativity in the final design product. According to this table, the validity of the model has been confirmed since the factor loadings are greater than 0.3 and the T-value is greater than 1.96. A factor loading is a value showing how the relationship between a latent variable and the corresponding observed variable is during the path analysis process. The higher the factor loading of an index concerning a given construct, the greater the role of that index in the explanation of that construct. Also, the negative factor loading of an index indicates its negative role in the explanation of the relevant construct. In other words, the question about that index is designed to be inverted. One of the outcomes of factor analysis is called the factor matrix. Factor loading can be considered the correlation coefficient between the factor and the variable, and factor loadings less than 0.3 can be ignored.

**Table 11.** Results of Confirmatory Factor Analysis of the Effective Components in Assessing the Creativity of the Final Design Product by Standardized Coefficients and Significance Coefficients

| Components | Standardized coefficient | Significance coefficients |
|---|---|---|
| Right imitation of previous samples (use of their desirable features) | 0.551 | 2.84 |
| inattention to the style of the day (not following the dominant fashion style) | 0.533 | 11.77 |
| Responding to all issues raised in architectural design | 0.554 | 3.26 |
| Communication with public opinion and belief (fluidity) | 0.460 | 4.28 |
| Coordination between design product and its function | 0.526 | 6.83 |
| Use of modern technologies | 0.569 | 3.20 |
| Providing an appropriate cultural solution (attention to the context of the design and the common culture in the region | 0.544 | 6.69 |
| Providing a suitable climatic solution (attention to the context of the design) | 0.447 | 4.91 |
| Use of contradictions to make the design outstanding in its context | 0.507 | 4.57 |
| Sensory enrichment of the subjects, induced by different spatial stimuli | 0.494 | 6.64 |
| Creating diversity and flexibility in created spaces | 0.557 | 3.95 |
| New form + New concept | 0.520 | 2.49 |
| New form + new function (balance between form and function and lack of dominance over each other) | 0.612 | 2.46 |
| New function + New concept | 0.649 | 7.53 |
| New form + new concept + new function | 0.604 | 9.94 |
| Relationship between the design product and the architectural area programming) | 0.628 | 4.25 |
| Being mysterious (as opposed to the explicitness of spaces) - innovativeness of spaces" | 0.446 | 3.37 |
| Using the originality of indigenous patterns | 0.543 | 6.64 |
| Quality of expression/presentation (appropriate writing and speech on the product) | 0.558 | 3.51 |
| Quality of expression/presentation (appropriate writing and speech on the product) | 0.568 | 2.46 |
| The visual connection between the design form and the design subject | 0.474 | 5.12 |
| The conceptual relationship between the design form and the design subject | 0.436 | 4.12 |
| Favorable quality of each designed space | 0.496 | 6.81 |
| Artistic, metaphorical and abstract answers to the design problem | 0.567 | 2.77 |
| Utility (efficiency) of the design | 0.530 | 2.81 |
| Innovativeness of the final product (no imitation of similar previous samples) | 0.410 | 3.68 |
| attention to the design and construction time (minimum implementation time) | 0.557 | 5.68 |
| Being economical | 0.557 | 2.41 |
| Oral presentation and critical reasoning of the designer in describing the creative aspect of the design | 0.554 | 3.56 |

## CONCLUSION

Review and analysis of the theoretical literature on the research topic and examination of propositions in diagrams and tables have led to the following results. To answer the research question, qualitative coding and expert judgment were used and statistical analysis was applied using SPSS software. In the first stage, by studying the relevant books, reviewing previous studies, and using the open-ended questionnaire, the components of creativity assessment in the architectural design were extracted. In the second stage, the effectiveness of the obtained components in the architectural design process and their final product was scrutinized and verified by collecting the opinions of experts and professionals using a researcher-made, closed-ended questionnaire. Then, the relationship between the variables was analyzed considering the research purpose, and the Spearman's correlation coefficient between creativity assessment variables was investigated. According to the results, the architectural design process is divided into five stages: "cognition and perception", "imagination (unconscious mind)", "in-between (distance between unconsciousness and consciousness)", "intellection (consciousness)" and "final decision based on individual evaluation". Despite the separation of these different steps, the design process is a fluid, nonlinear, flexible, and reversible flow. The results indicate that all the components are effective and highly important, and of course, some components are also important in two or more stages according to experts. In the "recognition and perception" stage, the components of "problem recognition", "right understanding and framing of the problem", "optimal use of site potentials", and "attention to climatic and environmental information" were found to be more important than other components, indicating the importance of preliminary studies carried out to understand the design subject before entering the design stage in architecture ateliers. The "innovation (uniqueness of the idea)" component in the "imagination (unconscious mind), and the "use of metaphor and amphibology (abstract thinking)" component in the stage between unconsciousness and consciousness were the most important components proposed. The results also indicate that the components of "having coherent theoretical foundations during the design process", "attention to the future", "attention to primary data" are more important components in the "consciousness (intellection)" stage. Moreover, the components of "the optimal use of site potentials", and "attention to climatic and environmental information" which were raised in the "recognition and perception" stage, are also of great importance in the "consciousness" stage. Thus, in the stage of the latency of the design idea in the designer's mind, it is very effective to face multiple sources of inspiration and receive knowledge from various sources. In the "final decision based on individual evaluations" stage, the "quality of expression/presentation (appropriate writing and speech on the process)" was foundto be the most important component. All these components are of the highest importance according to experts and professionals, and paying attention to them in architectural design workshops can increase the creativity of novices.

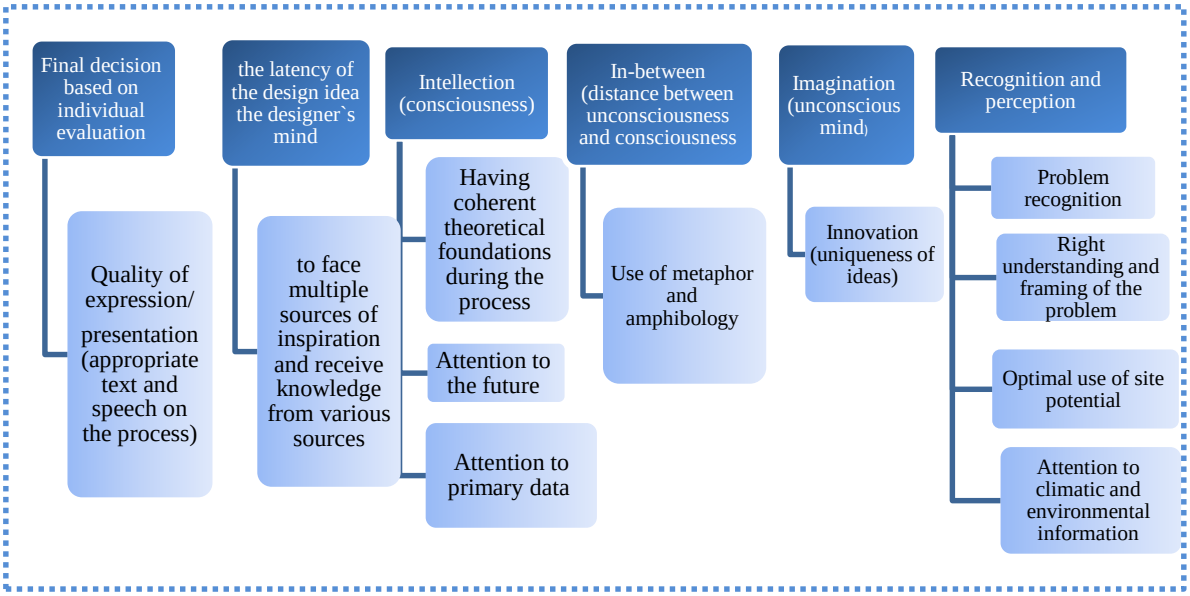


**Fig 11.** Improving the Creativity of Architecture Novices Regarding the Components within the Steps of the Fluid, Nonlinear, Flexible, and Reversible Flow of Architectural Design Process

Regarding the final architectural design product, the results indicated that the components of "the conceptual relationship between the design form and the design subject", "providing a suitable climatic solution", "providing an appropriate cultural solution", "favorable quality of each designed space", "coordination between design product and its function", "the visual connection between the design form and the design subject", "innovativeness of the final product (no imitation of similar previous samples)", "utility (efficiency) of the design", "responding to all issues raised in architectural design", "new form + new concept", "creation of diversity and flexibility in the created spaces", "new form + new function (balance between form and function and lack of dominance over each other)", "new form + new concept + new function", and "new function + new concept" were the most important components in assessing the creativity of novices according to the experts and paying attention to them in architectural ateliers can stimulate students' creativity. Charts 11 and 12 answer the main research question, show the result of this research and introduce the components effective in assessing student creativity in architectural design.

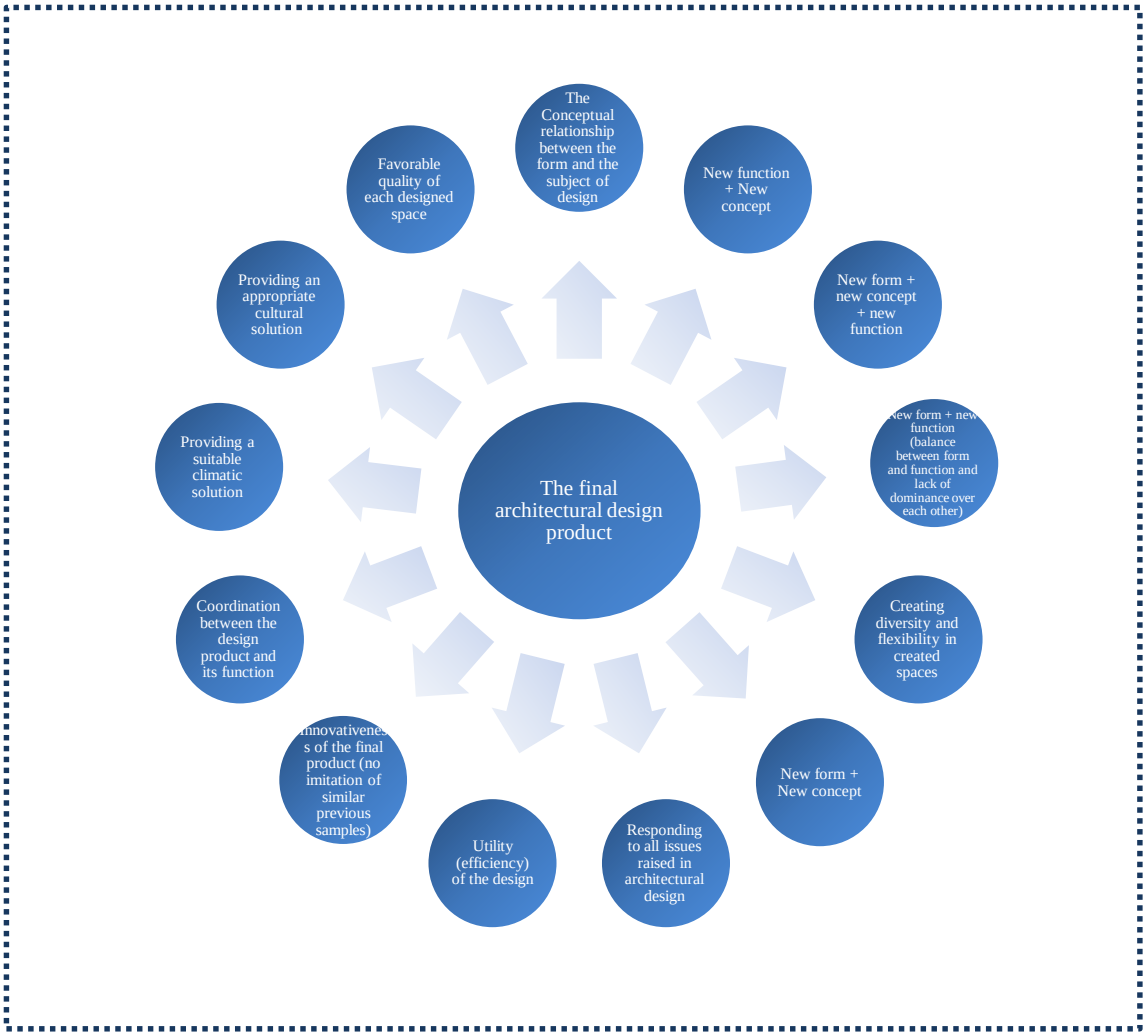


**Fig 12.** Components Assessing the Creativity of Architecture Novices in the Final Design

## RECOMMENDATIONS

The statistics and results of this study are mostly obtained from one country (Iran) based on the experts' opinions, but as a generalization of the questionnaire has been confirmed, despite the similarity of the human perception method, it is recommended doing this study in countries with different contexts compared to Iran to reveal differences due to influence of the culture, and historical and educational background.

Of course, according to the opinions of experts, it is recommended to examine issues such as the role of experiences in problem-solving ability, the role of mental archives, and previous observations in students' ideation, ideation in the first academic years regardless of structural issues, the role of the economy in design, the role of hidden memory in ideation, the need to pay attention to the elements of construction technology in the ideation process, prioritization of the steps according to the specific goals of each project, the influence of the employer or supervisor on the design process, the effect of the design subject on the effectiveness of creativity assessment components, attention to the student's knowledge of architecture in the process of creativity assessment in future studies in the same field.

Since design research is a new field of knowledge, and there have been few studies in this field and there are still hidden angles of it, for future research, the present research suggests studying the impact of the creative environment on the creativity of architectural design novices in the design studio and also investigating the methods of architecture novice creativity development.

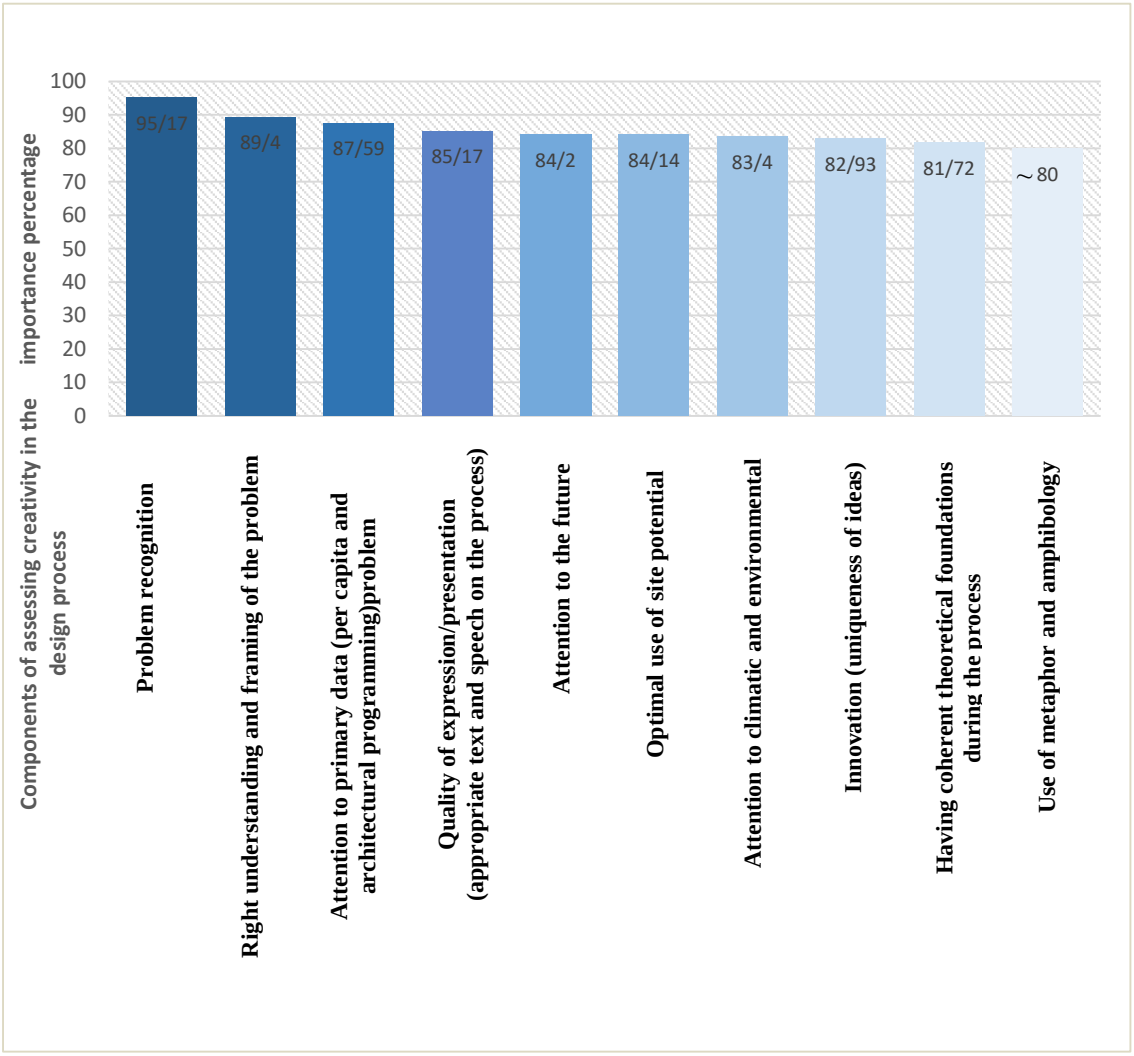


**Fig 13.** The Degree of Importance of Effective Components in Assessing the Creativity of Architecture Novices during the Architectural Design Process

Figure 13 is useful for teaching methods in architecture ateliers; in this case, spending time on knowing various aspects of design problems will be effective in innovative creation. Also, novices' idea-creation skill is developed through constant and diverse experience, collective criticism, and individual intellectual autonomy of students. Figure 13 also implies the importance of expression quality and abstract thinking for creativity in the design process.

Figure 14 emphasizes coordination between form and function, the degree of conformity with the environment, and the quality of spaces created at both part and whole scales for assessing the creativity of the final architectural designs. Although absolute agreement and consensus in judgment do not show the creativity and novelty of architectural designs, a relatively successful design product will be obtained based on the criteria presented in this figure, in addition to the characteristics and preferences ruling any place and community based on the mental memories and intellect and familiarity with certain forms and relationships. It should be considered that the control rate of the designer over the rhetorical tactics and techniques for persuading the audience and justifying the design can influence the minds of assessors.

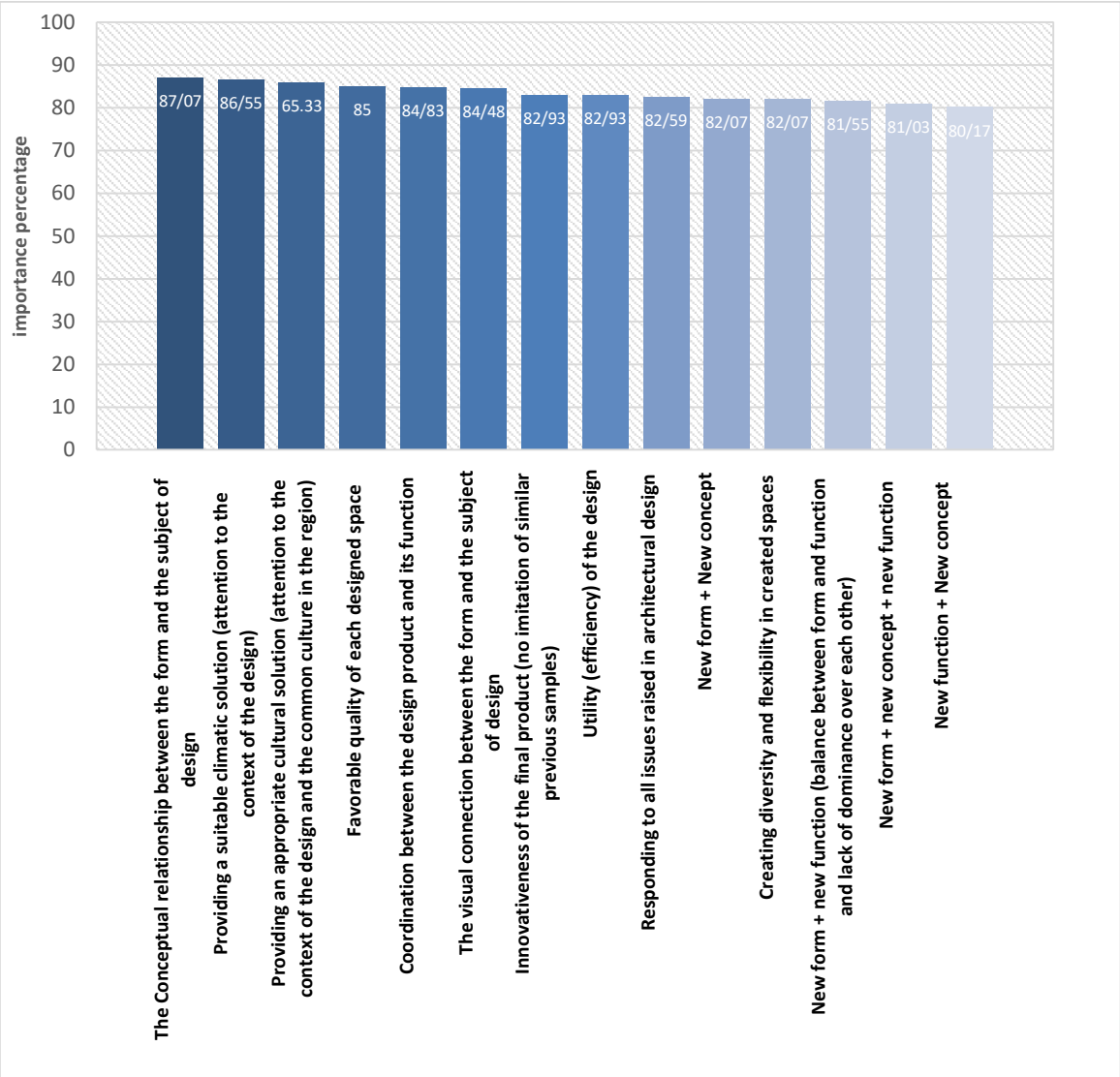


**Fig 14.** The Degree of Importance of Effective Components in Assessing the Creativity of the Final Architectural Design Product

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**AUTHOR (S) BIOSKETCHES**

**S. Tayyah.,** *Department of Architecture, Rasht Branch, Islamic Azad University, Rasht, Iran*
Email: *Tayyah@iaurasht.ac.ir*

**F. Mehdizadeh Saradj.,** *Faculty of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran*
Email: *mehdizadeh@iust.ac.ir*

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