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Studying the Obstacles of the Formation of Interactive Architecture Emphasizing at Virtual Reality Technology in Tabriz, Iran

Roghayyeh Khabbazi[1], Solmaz Babazadeh-e-Oskoee[2], Asadollah Shafizadeh[3], Shabnam Akbari Namdar[4]

1. Department of Architecture, Ahar Branch, Islamic Azad University, Ahar, Iran. E-mail: ro.khabbazi@iau.ir
2. Department of Architecture, Oskoo Branch, Islamic Azad University, Oskoo, Iran. E-mail: Solmaz.babazadeh@iaut.ac.ir
3. Corresponding author, Department of Architecture, Ahar Branch, Islamic Azad University, Ahar, Iran. E-mail: a-shafizadeh@iau-ahar.ac.ir
4. Department of Architecture, Tabriz Branch, Islamic Azad University, Tabriz, Iran. E-mail: Namdar@iaut.ac.ir

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ABSTRACT

For a long time, in the process of architectural design, mutual understanding between designers and users has always had problems and dilemmas, and most of these obstacles and problems were due to the lack of suitable interactive and communication tools and facilities. Therefore, it is necessary to use the inherent ability and potential of virtual reality technology in order to establish interactions and mutual and two-way communication. The present research has been carried out to investigate about the principal obstacles in the formation of interactive architecture emphasizing at the use of virtual reality technology. Considering the importance of technology in architecture, the purpose of this research is to evaluate the basic shortcomings in the formation of interactive architecture and the promotion of human interactions, emphasizing the benefit of virtual reality technology. The research method in the present research is mixed (quantitative-qualitative) with practical purpose and analytical-exploratory nature, in order to analyze the information, partial least squares model was used in Warp-pls software. The findings of the research show that among the basic obstacles of the formation of interactive architecture with an emphasis on virtual reality technology, we can point out the lack of attention to architectural contexts, the lack of attention to identity building goals and the lack of complementary interaction between architecture and nature. Therefore, in order to realize interactive architecture, to improve human interactions and also to increase the sense of belonging to the place of application of virtual reality technology in all kinds of architectural designs, taking into account the design fields, it is necessary to create a relative balance between all factors and pay attention to the development in the future.

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Introduction

Interactive architecture deals with designing and construction of spaces that adjust with changing needs and conditions of individuals, surrounding environment, and the society they live in the exchange of data between two systems (two humans, two machines, a human and a machine) is known as the basic principle in an interaction (Boychenko, 2019). The major point regarding interactive architecture is the fact that the interaction between them should be in the form of a cycle, or else the interaction would not happen and solely there would be a reaction (Fox, 2010). An interactive system is a multiple loop system that involves a person in a conversation, a type of communication which entails constructive and consecutive data exchanges. These systems are dynamic systems through which the data are constantly exchanged, the environment and the system are affected by each other all the time, and the responses are not pre-determined. Such a system is able to promote outputs throughout the time and through the interaction and complete relationship with inputs received from the environment. On the other hand, interactive architecture not only is able to respond the preplanned requirements, but also can enhance humane interactions and can introduce culture and art and architecture to all over the world and enables its users to have a flexible role in forming the environment (Liang et al., 2021). This means that an interaction happens between human beings and environment in interactive architecture. Also, through understanding the approaches and origins of interactive architecture we can conclude that this specific type of architecture designs electronic and virtual terminals to create spaces through which a two-way interaction between human beings and architecture is established (Sutny et al., 2019). Furthermore, it should be noted that in interactive architecture, the interactions between humans and accessibility of the target and the major identity of the design are considered and the interactions between the inhabitants and the technology promotions are known as the key points in success of architectural spaces (Stanica et al., 2018). Therefore, it could be stated that technology known as a tool to achieve desirable goals has tremendously changed the conception method of individuals of the world, and the type of relationship between them and the lifestyles and it has affected the different aspects of human life in a way that some believe that human beings and the world would be dominated by technology in a near future (Telma and Pacheco, 2009). In a more limited scale and in architecture which is an interdisciplinary scientific field, an interference of technology regarding the dependency of architecture to material world and thus observing natural principles becomes necessary. In a first glance, technology is considered as a machinery but if we do deep into the topics revolving around it, it can be revealed that this concept entails a vaster range through which in architecture there exist theoretical fundamentals, thoughts and designing processes, instruments and tools, machinery and finally the ending effect (human interactions) (Knox, 2017).

Thus, in the present era, using technology and virtual reality system have introduced a novel logic within architecture that could be tangible regarding current advances and the current era advances have been very prevalent and have resulted in developing interactive architecture. Meanwhile, although the boundaries between reality in the world and the effect of technology in interactive architecture have been changed, we cannot observe a fundamental thought change trend in Iran regarding such a relationship and we seriously feel the need to use such a technology in Iran. To do so and regarding the role of technology and virtual reality tools in interactive architecture, the present study tries to investigate about the basic obstacles of interactive architecture formation emphasizing at utilizing virtual reality technology. Therefore, the research question can be stated as follows:

What are they the basic obstacles in the formation of interactive architecture with an emphasis on benefiting from virtual reality technology?

Research Literature

There have been many researches done regarding interactive architecture during some recent years. Meanwhile, the emphasis on technology in this field and virtual reality has complemented interactive architecture gap in the previous research literature and the present study has been carried out aiming at investigating about the basic obstacles of interactive architecture formation emphasizing at utilizing virtual reality technology. Below, we will refer to some of the closest local and foreign research projects related to the topic mentioned above.

Jelvani Esfahani (2016) carried out research investigating about the characteristics of interactive architecture in order to create a relationship between the user and the environment and architecture space and concluded that interactive architecture utilizes technology and novel digital tools that affect the behavior of humans towards his surrounding environment that increase the belongingness feeling of humans towards the environment. Zafarmandi and et al. (2021) investigated about the application of smart tools in interactive architecture designing in Tehran. Their results represented that the correlation coefficient in interactive space variables and smart materials' characteristics is in an assurance level of 95% and above 0.7 and thus we can identify a variable through describing another variable. The highest correlation score was between temperature and location dimensions amounting to 0.938 and the least amount was between energy and body pressure variables. Lalbakhsh et al. (2022) carried out a study on proposing an architecture design training model based on cooperative and interactive thought in Iran and concluded that architecture designing using cooperative and interactive methods emphasizing at novel technologies has resulted in better efficiency of architecture training among the graduates in the field. This is due to the fact that in such training the distance between academic training and daily lifestyles of the graduates has become shorter and it has led to create much more correlation among those graduates. Bullivant (2005) carried out research on

architecture designing, technology and interactive architecture and found that the truth of interactive architecture lies in the much more integration of levels in current era communications through computer and information technology world and the principles of intellectual perspective of architecture. Therefore, current era architecture deals with integrating architecture and dynamic world and the correlation between them and above them all, the presence of interactive architecture as the major sample of information technology. Rocker and Kai (2012) did a research project on technological aspects of smart houses and the integration of smart information levels regarding an architectural environment and observing the outcomes to investigate about the effect of interactive architecture in smart houses. Results showed that the vast relationship between the different data resulted in interaction between users and the environment and different spaces in houses. However, making them smart has resulted in houses to lose identity in cultural aspect. Xie and Ding (2023) probed on the interactive approach to create space architecture designing based on Graph's theory. Results of producing the designs showed that the proposed method could create a space through which when the relationship between volumes has been adjusted correctly, there would be a rich experience. Domijan and Maric (2024) did research on interactive architecture as approaches to organize the conception and concluded that regarding the convergence in viewpoints of the designers and users in interactive architecture and utilizing smart tools we can achieve perceptual organization in architecture spaces.

Theoretical Foundations

In interactive architecture, the interaction between objects and space is able to change the expanding demands of humans, society, and the environment and a two-way interaction is created with the users and they can adjust themselves with the needs of the other individuals and the environment. Understanding and knowing how to communicate and exchange information between users, materials and tools in architecture and the surrounding environment of the building, can identify the characteristics of administering and activities being carried out in the environment and finally this could lead to discover their interactional relationships and to understand the four principal features of interactive architecture as follows: timing, learning, remembering, and creating (Amini, 2018). In fact, interactive architecture is comprised of assimilation and integration of a set of calculation approaches and methodologies and a physical body. The integration of these two lets the environment to achieve a higher level of changeability and to react the changes automatically, to react against them and to adjust with them and to achieve interaction. Supposedly, interactive architecture can be attributed to buildings and constructed spaces that are able to create an active communication between the users and their surrounding environment (Jaskiewiz, 2013). Also, interactive architecture is known as a type of background architecture that investigates about all three major elements of location sense-meaning, application, and physical environment and creates spaces that entail all three elements

mentioned above (Kandemir, 2016). On the other hand, interactive architecture deals with the efficiency of digital terminals to make decisions regarding the human beings' lifestyles and how do they affect their life. The future is thought to create environments and tools that are not fixed and they can respond to different individual, social, and environmental needs (Fox, 2020). Also, one of the basic features of interactive architecture is that it is cooperative and also cooperation seems crucial. Accordingly, the users, customers, and citizens cooperate within the process of designing. Due to this, their mental images of the spaces are extracted and then they are utilized to create new locations and spaces. On the whole, the basic principles of interactive architecture are as follows (Ekhlasi and Ghamari, 2011):

1. Considering designing aspects;
2. Comprehensive and paten perspective regarding different aspects of designing process;
3. Discovering and understanding the relationship between different elements and their analyses;
4. Creating multiple interactive relationships between all the elements;
5. Flexibility and adjustability;
6. Creating relative equilibrium between all elements;
7. Revising design limitations;
8. Paying attention to development in future.

Fox (2020), states that in nowadays era, the use of virtual reality is considered one of the important tools for the formation of interactive architecture and the realization of its principles. In other words, virtual reality imitates the real working scene and improves the cognitive structure (Li et al., 2017). It also creates some opportunities that can be used as a controllable device and not dangerous to understand the human beings in relation with space and creating locations to implement them through space learning (Sutny et al., 2019). Also, Virtual reality, along with advanced information technology can simulate appropriate spaces in a smart way and enable an individual to carry out activities that are impossible in real world (Bakshi et al., 2020). On the other hand, through integration of virtual reality and artificial intelligence, some new fields are created and this enables space users to experience the phenomena that are impossible in real world. Also, it does not include bodily or financial dangers and this opportunity is proposed to the individuals through which they can experience concepts that were very difficult or impossible to do so in real world (Layer et al., 2012).

In general, it can be said, which in 21st century, the world has almost completely been controlled by technology in all aspects of life (Mondal et al., 2019) and progression and development in technology in architecture has been very prevalent and has led to effectiveness and efficacy (Chen et al., 2020). In this regard, as technology is progressing very fast during the current era and many of human reactions are taken from the object world into the virtual world,

the formation of a virtual world is increasingly developing and the goal of architecture is to form such a world and make it hospitable aiming at increasing interactions (Ekhlasi and Ghamari, 2011). On the other hand, using virtual reality system in architecture has created a new logic following the recent advances in the field which create feeling promotion spaces which are abstract and very tangible at the same time. Therefore, using virtual reality tools in architecture can create a novel dimension of technology and architecture interactions (SajjadiZavieh and Nili, 2013). In other words, virtual reality is deemed something such as living dreams and it leads to the formation of interactive architecture. Accordingly, Mccloy (2014) has emphasized at scientific and practical knowledge and Andriani and Cohen (2013) have stressed on technique, industry, and mental paradigm in realization of interactive architecture in technology and virtual reality. Also, based on the view of Lee et al. (2017), the nature of interactive architecture using virtual reality system is an attempt to create interaction to find solutions. In this process, it is tried to use optimal solutions by collecting and classifying suitable answers. Also, since architecture is a multifaceted and complex process and includes both knowledge and creativity; at first, the architect creatively presents the initial plan by using her mental ability, then by sharing the plan, before building the spaces among the users, by comparing the activities and emotions of the users and analyzing and evaluating the choices of the users, drives the design into a process of creating more human interactions.

Research Method

The research method in the present study is a mixed-methods (quantitative-qualitative) type aiming at functionality and it has an analytic-extractive nature. Accordingly, first the obstacles of the formation of interactive architecture emphasizing at technology of recognition were identified and then a questionnaire was presented to the statistical sample and the most important components of these obstacles were identified. It should be noted that, regarding the location of administering the present research which has been Tabriz, the statistical population of the current research involved architects and university elites and due to the fact that the number of participants were not predetermined, we have used Cohen's formula in an assurance level of 95% to determine the sample.

Cohen's Formula

$$N = Z^2S^2 / d^2$$

Where, Z is a fixed amount depending on the assurance distance and error level (α). Considering the identification of assurance distance of 95 percent, d is equal to 0.05 and Z is equal to 1.96. Also, S refers to primary sample variance gained from questioning 20 primary samples. Based on calculations carried out, the variance of the primary sample was calculated to be equal to 0.255. After putting the amounts in formula above the sample was calculated to be

equal to 100 persons and the accessibility to this sample was based on a purposeful non-random sampling method.

N = (3.8416 * 0.0650) / 0.0025 = 100

Also, in this research to measure the internal validity, first the content validity method was used to increase questionnaire validity. To achieve this, the tested indices utilized in the previous research projects were studied and the scholars' views were asked. Then, the organized questionnaire was completed in two preliminary and complementary stages and after studying the responses gained from 30 preliminary questionnaires and carrying out the required statistical calculations, the final questionnaire was devised. To analyze and study the precision amount of questionnaire questions and to measure the appropriateness of analysis tools in the present study, the reliability analysis method of alpha coefficient of all the question items were calculated. Based on the calculations carried out, the alpha coefficients of all questionnaire questions were bigger than 0.7 and the total alpha coefficient was equal to 0.783.

Also to analyze the data we have used the least square model in Warp-pls software and the indexes of Table 1. The questionnaire in this research was based on Likert's 5 item indices.

Table 1. Obstacles of the formation of interactive architecture emphasizing at technology

Elements	Indexes	Sources
Lack of attention to structural goals (A)	Lack of formation of interactive approach between Q1, specialists, lack of attention to material and spiritual needs of humans Q2	(Al-Bayari and Shatnawi, 2022)
Lack of organizing the perspective (B)	Lack of space flexibility Q3, lack of proper relationship between different spaces and unity Q4	(Fritsch, 2011)
Lack of attention to identity maker goals ©	Lack of architecture creativity in different types of geometry, new and novel elements and constituents Q5, lack of variety while being stable that means using contractive symbols, simulation and summarization, form-image and content-conceptual that means an appropriate interaction between spirit and meaning with the body and surface Q6	(Farhad et al., 2021)
Lack of attention to aesthetic goals and abstractness (D)	Lack of use of most abstract material elements and ornaments to pay more attention by the humans to spiritual issues Q7, lack of attention to abstract issues specifically in drawings and using the original geometry Q8	(Fox, 2020)
Lack of completion	Lack of complete respect and caution in dealing with	(Kasmer et al., 2013)

interaction between architecture and nature (E)	nature Q9, lack of complete exploitation of varied weather conditions, reconstruction and recreation of green nature in architecture skethesQ10	
Lack of attention to architecture fields (F)	Lack of using traditional culture and traditional architecture in designing Q11, lack of paying attention to the preferences of the users Q12	(Farhad et al., 2021)
Lack of unity (G)	Lack of understanding and discovering the relationships and creating the relationship between different elements Q13, lack of appropriate relationship between employer, designer, and user Q14	(Passey, 2006)

Source: Documentary studies of the authors, 2024.

Regarding the partial least squares model, it could be stated that the model can be presented in two sections as follows:

Analysis and interpretation of the structural model: A structural equations model that uses partial least squares (PLS) method should be analyzed and interpreted in two stages. First the measurement model will be analyzed and interpreted and then the structural model will be analyzed and interpreted. By investigating measurement model, we mean the probes of weights and loads of the hidden variables and by investigating the structural model we mean analyzing the route coefficients between hidden variables.

Measurement model analysis: In this stage, it could be identified that whether the theoretical concepts were precisely met by variables or not. To do so, their validity and reliability were investigated. In PLS model, individual reliability of each item for constructs, internal consistency, and convergent validity and divergent validity are analyzed.

Finally, after presenting the statistical data and results, we have dealt with investigating the samples of novel buildings' architecture to document the results.

Discussion and Findings

Obstacles of the formation of interactive architecture emphasizing at technology

Validity of the hidden variables

Validity of each of the hidden variables in PLS model is determined through the amount of weights of each variable. The value of each of the element weights of the hidden variables should

be greater than or equal to 0.5. In Table 2, the amount of element weights for indexes of hidden variables of the study could be observed.

Table 2. Weight value of the indexes of hidden variables (Source: authors, 2024)

Hidden variable Observed variable	A	B	C	D	E	F	G	P-Value
Q_1	0.721	0.237	0.082	0.172	0.077	0.315	0.288	<0.001
Q_2	0.721	-0.273	-0.082	-0.172	-0.077	-0.315	-0.288	<0.001
Q_3	0.235	0.742	0.271	0.147	0.249	0.075	0.146	<0.001
Q_4	-0.235	0.742	-0.271	-0.147	-0.249	-0.075	-0.146	<0.001
Q_5	0.085	0.181	0.735	0.401	0.152	-0.262	0.079	<0.001
Q_6	-0.085	-0.181	0.735	-0.401	-0.152	0.262	-0.079	<0.001
Q_7	0.263	0.244	0.191	0.719	0.273	0.178	0.009	<0.001
Q_8	-0.263	-0.244	-0.191	0.719	-0.273	-0.178	-0.009	<0.001
Q_9	0.156	0.118	0.156	0.244	0.754	0.391	0.247	<0.001
Q_{10}	-0.156	-0.118	-0.156	-0.244	0.754	-0.391	-0.247	<0.001
Q_{11}	0.284	0.257	0.312	0.254	0.227	0.708	0.112	<0.001
Q_{12}	-0.284	-0.257	-0.312	-0.254	-0.227	0.708	-0.112	<0.001
Q_{13}	0.073	0.208	0.152	0.079	0.087	0.411	0.762	<0.001
Q_{14}	-0.073	-0.208	-0.152	-0.079	-0.087	-0.411	0.762	<0.001

As it can be observed in the table above, all amounts of indexes related to the hidden variable in bold are higher than 0.5. Therefore, it can be stated that the measurement model has had enough validity regarding hidden indexes.

Structure validity (internal consistency)

To measure such a validity, the integrative validity index in PLS model is introduced. This index is calculated based on Cronbach alpha coefficient. The amount of this index should be greater than or equal to 0.7. Table 3 represents the validity amount of the structure for each of hidden variables.

Table 3. Validity of structures of hidden variables (Source: authors, 2024)

Hidden variable Structure validity	A	B	C	D	E	F	G
Integrative validity	0.746	0.751	0.783	0.715	0.745	0.741	0.753
Cronbach alpha	0.728	0.736	0.726	0.739	0.745	0.724	0.714

As it can be observed, all amounts of integrative validity have been calculated to be higher than 0.7. The amount of Cronbach alpha has also been presented in table 3 and it could be seen

that all these coefficients have been higher than 0.7. Therefore, the measurement model has had an appropriate structural validity level.

Convergent Validity

The convergent validity in PLS model has been extracted and analyzed through average variance index (AVE).

Table 4. Convergent validity of structures (hidden variables) (Source: authors, 2024)

Hidden variables Convergent validity	A	B	C	D	E	F	G
	0.732	0.718	0.622	0.691	0.763	0.581	0.719

Regarding Table 4, all average variance amounts extracted have been higher than 0.5 and therefore the measurement model has had an appropriate convergent validity.

Divergent Validity

To measure divergent validity, we investigated whether the extracted average variance amount (AVE) for each structure (hidden variable) has been greater than the second square of the correlation between that structure and other structures in the model or not.

Table 5. Divergent validity of the structures (hidden variables) (Source: authors, 2024)

Structure Structure	A	B	C	D	E	F	G
A	0.763	0.423	0.193	0.369	0.093	0.629	0.541
B	0.521	0.749	0.229	0.175	0.255	0.194	0.376
C	0.318	0.250	0.734	0.067	0.319	0.230	0.216
D	0.372	0.178	0.253	0.772	0.356	0.369	0.169
E	0.416	0.139	0.265	0.569	0.758	0.426	0.261
F	0.267	0.273	0.420	0.641	0.412	0.742	0.231
G	0.312	0.227	0.118	0.239	0.314	0.202	0.736

The amounts of the main diameter in table above show that the second root of AVE and other amounts have had a proper correlation regarding the structures. It could be observed that all structures have had proper consistency regarding the intended conditions. Therefore, it can be said that structures have had proper divergent validity. As it can be observed in table 5, the elements on the main diameter have had higher amounts than others.

Structural Model Analysis

In Figure 1, represents the structural model analysis, the coefficients of each of the routes are represented. Each of the coefficients will be acceptable if the amount of P-value is less than 0.05. Table 6. P-value related to each of the routes

Table 6. Meaningfulness of Route Coefficients (Source: authors, 2024)

Route	Route Coefficient	P-values	Result
A------ TIA	0.521	0.006	Approved
B------ TIA	0.472	0.009	Approved
C------ TIA	0.650	0.012	Approved
D------ TIA	0.403	0.014	Approved
E------ TIA	0.631	0.013	Approved
F------ TIA	0.712	0.042	Approved
G------ TIA	0.584	0.018	Approved

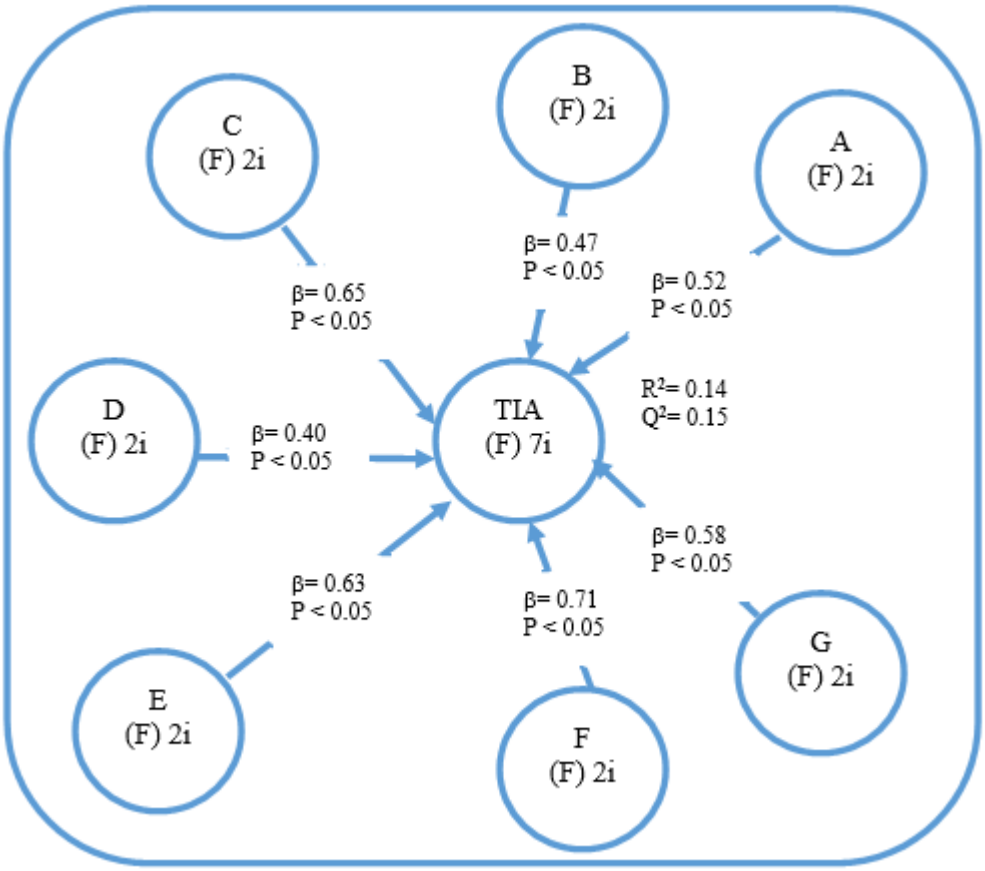

Figure 1. The Structural Model of the Research (Source: authors, 2024)

Table 6 shows the amounts of obstacles of interactive architecture formation emphasizing at technology. As it can be observed all 7 constituents under investigations are from among obstacles of the formation of interactive architecture emphasizing at technology within the study limits that have been approved with an assurance level of 95%. Furthermore, the most important obstacles were: lack of attention to architecture fields, lack of attention to identity maker goals, and lack of complementary interaction between architecture and nature and the coefficients resulted from the structural model of each were equal to 0.71, 0.650, and 0.63, respectively.

Table 7. Coefficients of identifying dependent variables (Source: authors, 2024)

Index Dependent variables	R^2
TIA	0.144

The prediction power of the designed model could be analyzed using the amount of coefficient for the dependent variables. The amounts greater than or equal to 0.1 were identified for the coefficient. Considering Table 8 we can conclude that the structural model of the present research has had enough power. In this model 14.4% of the variable variance of shortcomings of the formation of interactive architecture emphasizing at technology were justified through the input variables.

Table 8. Stone-Geiser Test (Source: authors, 2024)

Index Dependent variables	R^2
TIA	0.151

Based on Stone-Geiser Test, since the amounts of Stone-Geiser Test are calculated to be higher than zero, the model considered has had the required capacity and power for prediction. Stone-Geiser Test coefficient for variables of shortcomings of interactive architecture formation emphasizing at technology was equal to 0.151.

Studying samples in Tabriz considering the utilization of interactive architecture emphasizing at technology

In this part we are going to talk about two contemporary architectural locations regarding the perspective of interactive architecture and their technology. The reason to choose these two architectural areas and buildings is their attractiveness for the audience, novelty, and utilization of famous designers and advanced construction technology in addition to their validity.

Tabriz Blour Tower

Tabriz Blour Tower is one of the very first higher than 20 floor towers that has been designed by Doctor Aliakbar Saremi (one of the most experienced professors of architecture in the country and in middle east) in 2000 and the next year it was started to be constructed. This tower is known as one of the purchase centers and tourist attractions in Tabriz and it is used for business, official works, and services. Also, this structure with 25 floors is considered as one of the highest towers in Tabriz and is comprised of 130 business units, 112 office units, 4 conference halls, a turning restaurant in highest floor and a food court.

Regarding the simulation and virtual reality, the only three-dimensional image of this tower dates back to the time before the construction of this tower and there has not been any relation between the designer and users of this building in designing period.

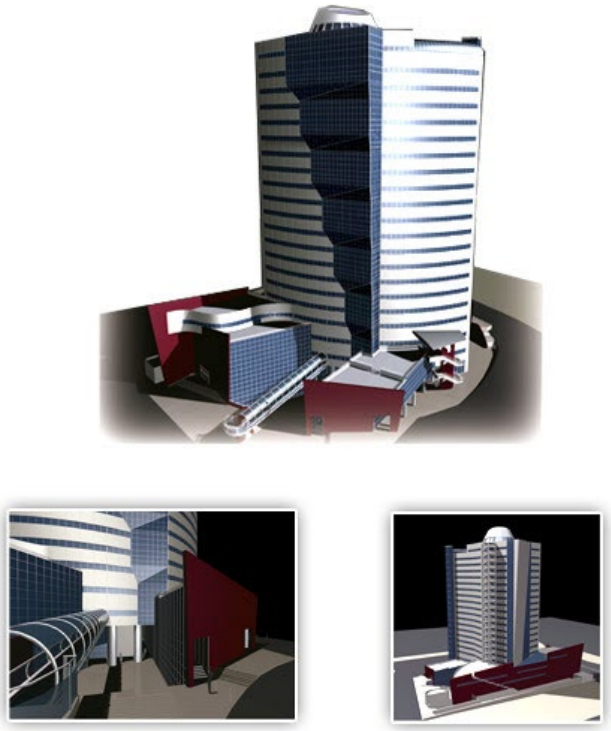

Figure 2. Three-dimensional image of Blour Tower (Source: authors, 2024)

Considering the relationship between humans, this architecture location has a proper status. However, the interaction of human and nature cannot be observed in this architectural space. Also, the construction technology of this location has international standards. This building has an optimal status regarding strength and beauty and citizens have stated in interviews carried out that it inspires a proper environmental understanding to them. Furthermore, this architectural space emphasizes at modern architecture and is far from traditional architecture approaches.

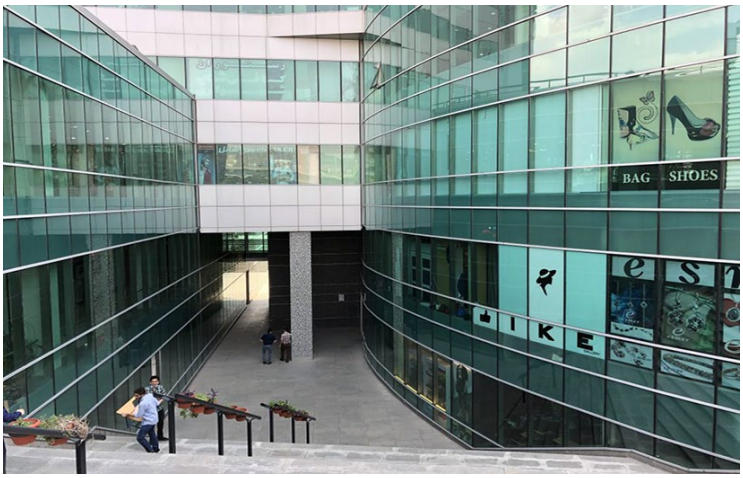

Figure 3. A picture of outer space of Blour Tower (Source: authors, 2024)

Figure 4. A picture of inner space of Blour Tower (Source: authors, 2024)

Tabriz World Trade Tower

Tabriz World Trade Center and Tower is considered as one of the greatest projects inaugurated in Iran and this gracious project lies within the heart of the ancient Tabriz. It is known as one of the most successful symbols on business constructions in Iran. This project has a hotel, business centers, recreation sections and conference halls. The construction of this structure started in 2007. The major building of this enormous complex includes 37 floors and with a height of 152 meters, it is known as the highest business, service, tourist attraction tower in west of the country.

The features of Tabriz World Trade Center are as follows:

- This center is the highest business, service, tourist tower in Iran with a height of 152 meters.

- It is the very first building through which the special ribbed ceramic panels' covering was administered in Iran.
- The first building with injected rebar connections of NMB type constructed in the country.
- The first high tower equipped with viscous dampers that attract earthquake energy in the country.
- It's the first building in the country built with a concrete having strength of 700 kilograms per square centimeter.
- It's the first building constructed using a hyper-strong rebar with a resistance tension of 7000 kilograms per square centimeter.
- It's easily connected with three western entrances to reach highways and major roads.
- It has a good access to local ways and urban service centers.
- It has more than 1500 covered parking lots and a considerable amount of open-air parking.
- It has used advanced R-PC technology in the structure.

It's the first building administered through the use of prefabricated porches using P-PC technology.

Figure 5. A three-dimensional picture of World Trade Tower (Source: authors, 2024)

Like Tabriz Blour Tower, there has only been a preliminary simulation and three-dimensional images recorded before the construction ending and there could not be any relations observed between the users and the designers of this tower. Also, the relationship between humans is desirable in this space and the relationship between human and natural environment is undesirable. Regarding technology, this building has used the latest achievements in designing this tower and it covers different aspects such as economy and ecology. Meanwhile, cultural backgrounds cannot be seen in this tower.

Figure 6. A three-dimensional sketch of World Trade Tower (Source: authors, 2024)

Figure 7. A picture of the major entrance of World Trade Tower (Source: authors, 2024)

In Figure 8, the latest sketch of World Trade Tower before the construction ending could be observed in this sketch, one cannot see the utilization of nature-based patterns and elements representing cultural backgrounds.

Figure 8. A picture of outer space of World Trade Tower (Source: authors, 2024)

Finally, it could be stated that some of the most important virtual reality terminals to form interactive architecture are the 360 degree rotating terminal, internal reflexive terminal, inspiring terminal or drowning terminal, mixed reality, and added reality system (Fritsch, 2011; Scharff and Val, 2014). The explanation for each of these terminals could be found below:

- ***360 degree rotating terminal:*** it has a mouse and a monitor or a projector and can represent three dimensional pictures with a possibility of 360 degrees rotation on the screen.
- ***Internal reflexive terminal:*** it includes a camera, a microphone and sensors that could simulate virtual world to the real world.
- ***Inspiring terminal or drowning terminal:*** it is inspired through the use of two visual screens equipped with stereophonic mobile phones and inspiring the presence in an environment in a more sensible style to the users through three dimensional pictures and voices.
- ***Mixed reality:*** an ideal system comprised of an integration of inspiring capabilities and far location recognizer and tracing systems and utilizing three dimensional and six dimensional patterns.
- ***Added reality system:*** in this system the sketch is so transparent that the user can observe the objects in real environment and in virtual world concurrently.

Studies have shown that 360 degree rotating terminal, internal reflexive terminal, inspiring terminal or drowning terminal have been utilized in designs and architecture in the selected areas

and the other terminals have not been functional. In other words, only the preliminary stages of virtual reality have been used in some of architectural designs trivially.

Conclusion

Virtual reality is in fact an abstract element and the users experience virtual reality through technology regarding the experience of environment understanding and the transfer and movement into another environment. When this technology is being used, the users are inspired in a way that as if they are present in the intended location regarding physics and body and can conceptualize abstract (virtual) objects and communicate with them. By presence feeling we mean a mental picture or awareness, the sense of being in a real environment or a virtual and abstract environment which often is considered as being present in the location. The receipt of highest presence feeling or the creation of such a feeling in the process of designing is seriously in a direct relationship with the development and expansion of designing methods. On the other hand, virtual reality creates the capability of gaining a proper understanding of the effects of three-dimensional locations when we decide in designing. Also, it could be stated that virtual reality technology as a tool for designing and studying the process of virtual designing using the technology deals with improving the relationships and reciprocal understanding between the designers and users. This technology relies on its intrinsic capabilities such as presence feeling to enter most of the fields specifically within architecture and simulation processes and can create tremendous effects in most aspects of human life and such effects are mostly positive and constructive for the future life of human. Meanwhile, studies have shown that in Iran the first stage of virtual reality that means images and three-dimensional sketches, have not been used in some projects and advanced integrated systems and added reality that identify the presence feeling of the users regarding different dimensions. Thus, interactive architecture whose prerequisite is the formation of technology and virtual reality in architecture designs has had a low realization capability. Finally, lack of formation of interactive architecture through virtual reality technology in Iran can be resulted from the following reasons:

- Lack of technical and supportive infrastructures;
- Lack of having the skill to use technology;
- Lack of public access to the technology;
- Resistance against changes and having negative viewpoints towards technology;
- Lack of knowledge and awareness regarding the advantages of using technology;
- Lack of having proper hardware;
- Lack of access to appropriate software.

The most important obstacles of current technologies in formation of the interactive architecture refer to: lack of attention to architecture fields, lack of attention to identity maker goals, and lack of complementary interaction among architecture and nature.

The most important shortcomings of the technology are: lack of attention to architecture fields, lack of attention to identity maker goals, and lack of complementary interaction between architecture and nature.

Based on what was pointed above and the results we can conclude that virtual reality technology is developing and become more complete every day. Thus, utilizing this technology in future in Iran within the field of architecture seems to be necessary. As science and technology is progressing in the present era and human beings are moving towards more uses of virtual world, using the modern era technology seems to be the most challenging thought for human beings in current age. This has been so severe that human beings are moved towards the age of digital humans. The useful application of technology and virtual spaces, in an atmosphere of populated urban areas not only removes the sense of being alone and changes human being into an entity without identity, but also creates a live and dynamic space within the urban architecture space where humans are moving towards much more sympathy and higher urban cultures and the consistency of identity of every nation. Therefore, it could be suggested to do more efforts to create more useful functions of technology regarding different aspects and recognize them and use these tools in architecture and other related fields in order to move towards optimal use of them. On the other hand, the following suggestions seem to be very necessary:

- Promoting technological skills among university students through fundamental changes in teaching trends;
- Emphasizing on appropriate interactions between technology, architecture, environment, and the user;
- Using technology in traditional architecture improvement and reconstruction and mending the monuments;
- Supporting plans and architecture technologies related with culture and urban structures;
- Using different techniques to form interaction and to create relationship between different lines of thought;
- Promoting public awareness in order to use technology;
- Localizing architecture technologies based on the field;
- Emphasizing the identity and meaning in architectural designs.

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All authors contributed equally to the conceptualization of the article and writing of the original and subsequent drafts.

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Not applicable

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Conflict of interest

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