

A Study on Mutual Effects of Digital Designing Process and Quality of Architectural Spaces

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Received: March 26, 2015

Accepted: May 17, 2015

ABSTRACT

The relationship between architecture and digital technology is a topic of vast discussion. As a new movement in architecture, digital architecture, has attracted increasing attentions due to its effective role in development of technology, innovations and architectural designing. Digital architecture is a sufficient innovation in the field of architectural designing and constructing purposeful and firm structures. The mentioned process has been hired in different steps of building designing including interior and exterior facades, mechanical floors, structural connections, interior connections, the sites of the complexes. Not surprisingly, the digital process has been welcomed and used by the majority of world's famous architects. Accessibility to ideal and purposeful buildings and standard designs are two main applying objectives of the process. The research method used in the present work is descriptive-analytic, in which it has been tried to cover all aspects of the subject by bibliographic studies on designed and performed cases such as Opera house of Sydney, the train station of Innsbruck, and the dancing house of Prague. The main findings of the present study can be used in architectural designing in a documented and qualified form.

KEYWORDS: "Digital Architecture", "Digital Spaces", "Designing Process", "Digital".

1. INTRODUCTION

Architecture is a digital movement which provides the ground for innovation and creation upon connecting architecture and digital science and unshackles the architect from designing architectural space with customary and ordinary past methods with previous drawing tools in the current era of speed-seeking and display the imagined details of a plan in advance. In several projects, structural system has no congruity with architecture of complex and topological forms of non-linear structures which are one of the effective thoughts in digital architecture and information era since digital architectural structures are progressing and construction systems in current era are stabilizing themselves and broking borders and these systems may not be able to meet the non-linear digital architecture requirements in near future.

Digital architecture enables the designers to do processing in computer with very high speed and create three-dimensional architectural spaces, evaluate and compare different choices with very high memory size in designing. In the end of past decade, the thought for using computer techniques are manifested in architecture such that it shows the effect of its index in minds and results of designers at least time. In details, it can be said that such assumption and such computer penetration in designing not only is effective in functional area of architects, it influence the other members of designing board and also influence the industrial designers, film makers and even musicians.

Nowadays, using digital can display all the assumed details of a plan in advance well which is almost impossible in past. Form is drawn in computer space, innovation is shaped, and Precipitous a shape is drawn manually in a space which is not so familiar while this space is an old friend that is computer space and an area for creating innovations. Architecture together with digital space encompasses the plans, the plans which manifest the digital architectural signs.

Digital architecture concept and epistemology

Digital architecture is known as architecture and space creation upon using the advanced graphical technology and facilities in computer which provides the opportunity for architects to created visual nature for complex settings without using physical models or customary Marquette's to increase the possibility for space imagination and assumption. Meanwhile, digital architecture is using computer and new technology tools for presenting geometrical structure of complex spaces which is resulted from the connection between architecture and computer.

Anyhow, digital architecture is considered as a tool for architect to enable Incarnation and reincarnation of uncustomary architectural volumes and forms which is considered as its basic different with Meta architecture since Meta architecture upon using computer intends to release itself from architect and be sufficient to its structure in spatial producing and reproducing though digital architecture is remained in architect's authority for expressing his opinions in creating space [1].

Digital architecture is recording the status change. It is recording of a moment from combination of destruction, developing form and structure in space. Virtual architecture means electronic representation of architectural design. Virtual architecture has several aims [2]:

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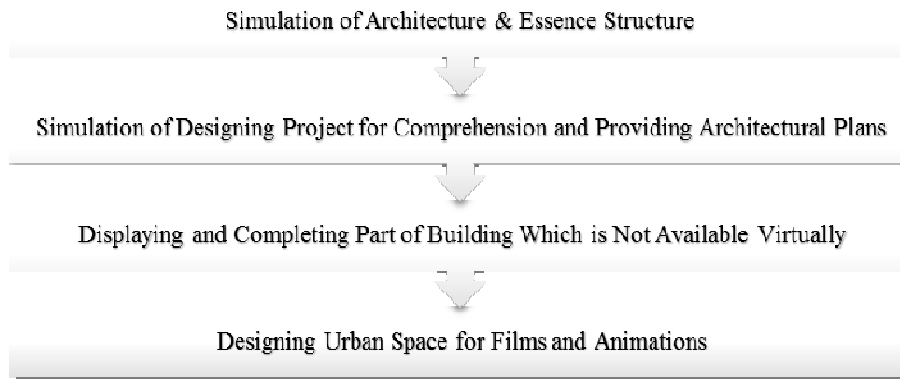


Figure 1: Goals in the phenomenon of architecture virtual

When we talk about digital forming, a question is raised automatically that is whether another power other than human mind can create form and idea? Forming means determining visual display and shape of building is the product and result of designing practice. So it shall be accepted that when we talk about another tool like computer for forming, in fact, a processor is made similar to human mind which can be put in human position and design.

It is necessary that at first we can mention a main difference which can lead to inaccurate judgment. When designer uses computer for drawing, developing and presenting his designing ideas, in fact, he uses computer as a tool for developing his ideas and thoughts and in such it cannot be said that computer in this process only compose part of the responsibility the design have.

From among digital forming techniques, we can mention the following ones:

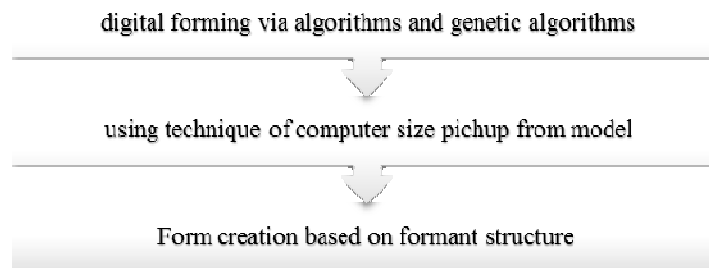


Figure 2: Techniques form troubleshooting Digital

From among digital design techniques, we can mention the following ones [3]:

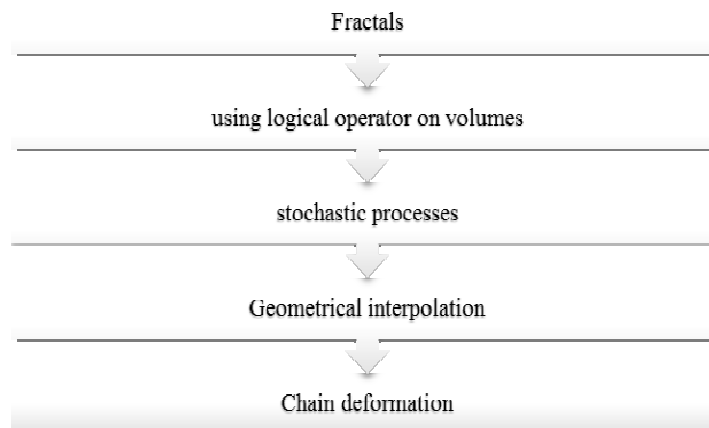


Figure 3: Techniques Designing Digital

Generally methods and processes of digital production can be divided into five main groups [3]:

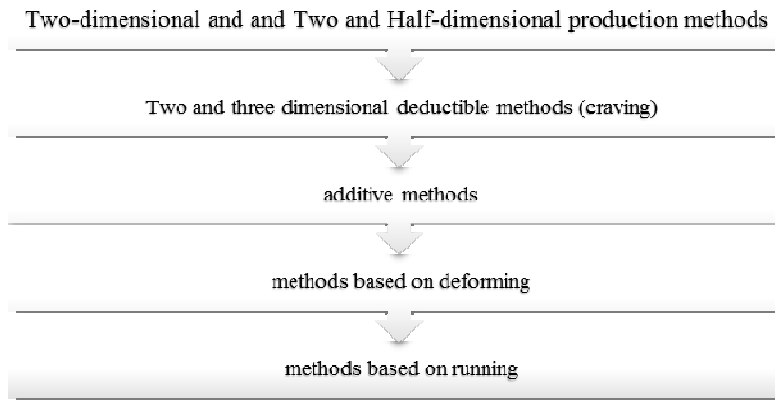


Figure 4: Process Production Digital at Digital Architecture

Manners of architectural presentation in an architectural office [4]:

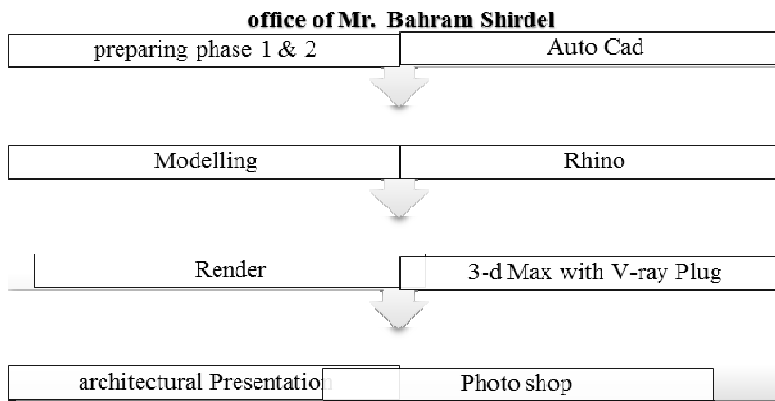


Figure 5: Presentation of architectural projects

Important points in digital architectural design

Computers add on the precision and range of architect practice to create a full and accurate architecture. Therefore, the computers shall not be look as accelerator. Producing diverse and numerous ideas by computers along with quickening the designing process increase the architectural work in some aspects and needs more work and precision. In this regard, architects with powerful and dynamic minds will be pioneers of future architecture. The ones who can move along with technological progress and show high power, choice and imagination of them.

In digital architecture, creation mostly depends on nature and possibility of media and accurate and wide connection of person with media (wide set of designers, programmers and users) to be effective in individual genius, the genius which will act compatible with virtual space [2].

Theoretical and conceptual discussions and effective thoughts in digital architecture

Charles Jencks • non-linear architecture → Charles Jencks is a non-linear architectural expression which is raised for new tendencies in architecture. These shapes have forms with curves beyond the recognized curvatures and can be produced via strong and advanced software. Charles Jencks published his next Best-selling book entitled as new paradigm in architecture immediately after this definition [5].

Paul Virilio • there is nothing else named as space. → As he said, in current era, means of communication are involved with electromagnetic waves and these waves can transmit the news signs in a speed equal to speed of light. Having assumed the instantaneous, data transfer appears at any distance on small land. Virilio expressed it as concurrency. The space is such that it cannot be available more in other others, breaking based on informing technology occurs in architecture which is used widely by critics [6].

Stephen Perla • Super level or virtual space → Super level theory does not look at virtual world as a space beside real space, while considers it as a reflection of a quantity which is available in transcendental objects inherently, the one which is manifested in architecture.

Perla resorts to a sentence by Toyo Ito in defining super level architecture." Emergence of different communicative technologies flow in our lives. The more influence of communicative technology on architecture and urban spaces, more movement is occurred on them".

Marcus Nowak • fluid architecture

Nowak is university professor and one of the pioneers of virtual world theory. He believes that architecture shall be fluid and water-like. The fluid architecture term which is very common nowadays is created since the beginning of electronic era and in 1985.

This idea is resulted from mutual connection of two available applied systems on that time. Simple applied software for drawing and printing two-dimensional data and stronger software which could do different operations at three-dimensional space. Nowak could create attractive figures in three-dimensional space upon using this software and presented special pattern [6].

Set of summing up the above theories in table No. 1

Table No. 1: digital architecture theories (source: editor, 2014)

Theorist	Theory	Reference	Theorist	Theory	Reference
Charles Jencks	Non-linear architecture	Klaroil, 2007, p. 57	Paul Virilio	There is nothing else named as space	Puglisi, 2006, p. 55
Stephen Prague	Super surface or virtual space	Puglisi, 2006, P.44	Marcus Nowak	Fluid architecture	Puglisi, 2006, P. 50

Literature and history of digital architecture

In this parts, it is tried to acquire a real view of the real world of digital technology attendance in architecture upon giving examples and studying the project in which successful procedure is passed in digital designing and production and also studying the problems of designing and executing these project. In fact, the main goal is scientific and experimental presentation of realities having used the digital technology including its successes and difficulties. Another goal of this part is mentioning the primary cases and theories on the obligation of using digital technology in architecture. It is certain that studying the experiences of others can help in clarifying the dimensions of the subject due to being new and maybe obscure.

In 1960's and 1970's, many plans have been executed with this method, from the most primary ones, we can mention the plan of Opera house in Sydney in 1973 (*Jørn Utzon*), menil complex in 1986 (*Renzo Piano*) research center of Schlumberger in Cambridge in 1992 (*Michael Hopkins*) Olympikia villa, Barcelona big fish in 1998 (*Frank O. Gehry*), Kansai airport in 1994 (*Renzo Piano*), Fred and Kinger building in 1996 (*Frank O. Gehry*) and finally central building of Saga group in 1992 (*Michael Hopkins*), it this part, Opera house of Sydney will be explained fully [3].

Studying designed and constructed case studies having used digital architecture

Project of opera house of Sydney and providing digital solution for solving architecture of building construction (image No. 1):

Utzon won in designing competition with plan in which the curved-shaped and crustal structure was design as sustainable arcs (image No. 2) which questions the manner of plan execution from the beginning (image No. 3).

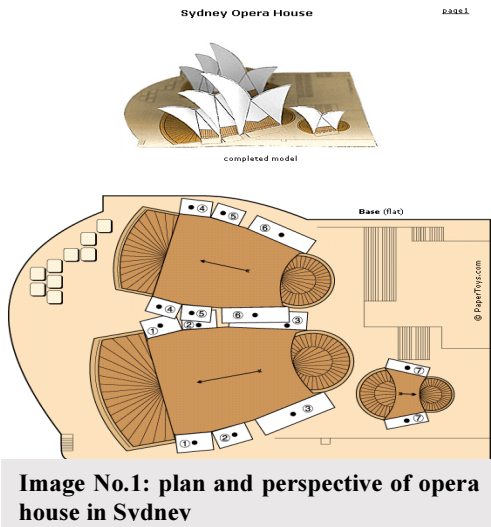


Image No.1: plan and perspective of opera house in Sdney

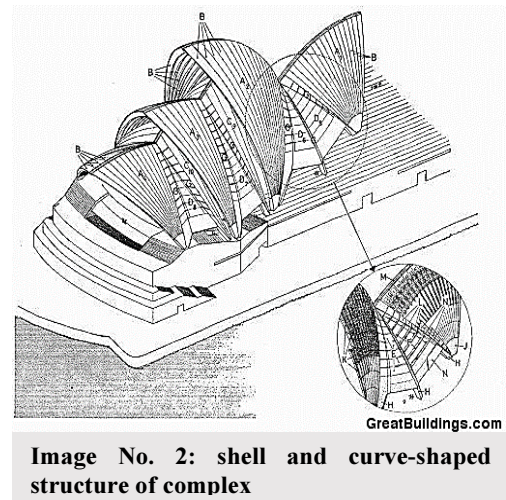


Image No. 2: shell and curve-shaped structure of complex

This complex plan challenges the designers and calculators of mentioned company who were responsible in plan execution in which the goal was finding method for executing this project (image No. 4). In fact, this building was opera house in Sydney which causes presenting a kind of pioneer software in designing with computer. Digital modeling provides the possibility of easier analysis of structure in considering the details of parts which were later connected to each other; for preparing comprehensive pattern which is the criteria in constriction. All important parts include the covering parts of crustal notched surfaces (image No. 5), steel structures system, glass parts and prefabricated parts of ceiling with full modeled details (image No. 6).



Image No. 3: manner of structural execution of complex

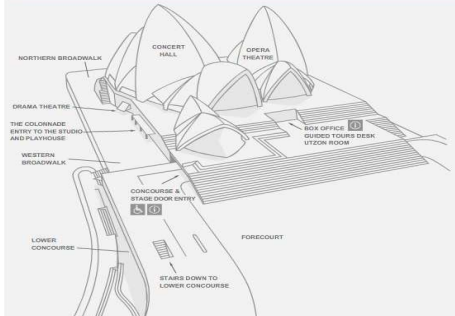
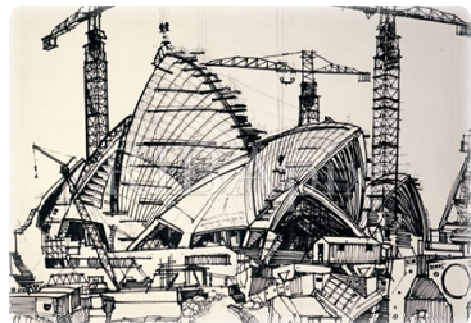


Image No. 4: layout of the complexity of plan



Image No. 5: view of the coated parts of shells surfaces



Computer modeling

From 1957 to 1974, architects, engineers and researchers at Melbourne University have tried in modeling the sail shell structure and analyzing the circular shape of glass surfaces of building upon using supercomputer (image No. 7).

Meanwhile engineers wrote program for structural analysis having used FORTRAN programming language. Therefore, computers started analyzing the shell of glass ceiling and walls. Computer modeling of glass cover and shell of opera house of Sydney causes shaping the system for estimation, measuring and analyzing very different parts of ceiling shell and combination of glass parts. In fact, engineers could computer dimensions at each part of building with computers such that finally these parts connected fully to each other and seem as a big, complex and uniform puzzle (image No. 8-10) [3].

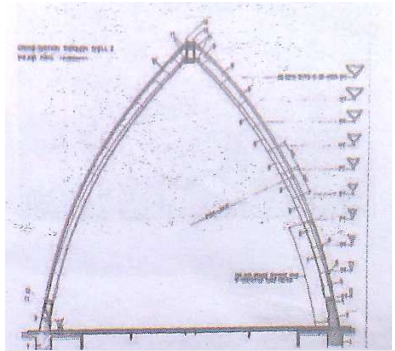


Image No. 7: computer modeling of sail shell



Image No. 8: manner of connecting structural parts to each other



Image No. 9: manner of connecting structural parts to each other

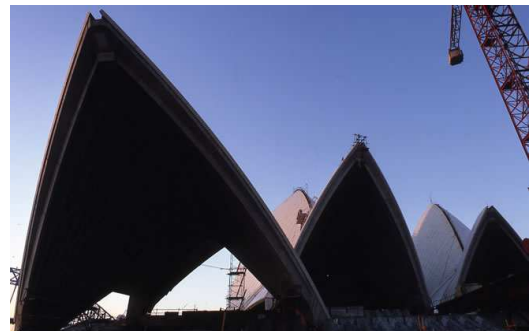


Image No. 10: manner of connecting and putting shells beside each other

Shape and dimensions of radial slots on coverage is changed from T shape to Y shape and their depth from 1.2-m to more than 2-, and their distance from each other from 0.9-m to more than 1.3-m (in tip of shells). In sum, the shells are divided into more than 2400 prefabricated parts (image No. 11).

Studying digital architecture case studies

Hungerburg station in Edinburgh (image No. 12)

Location: Edinburgh- Austria

Architect: Zaha Hadid

Designing & Construction Year: 2004-2007

In metro station of Edinburgh, Zaha Hadid consider stations made from glasses and all glasses were made and constructed with the same desired thickness, color and curve by precise computer systems (image No. 13). In this project, shell ceiling with free glass form is reminder of natural refrigerators and snow and perspectives (image No. 14). In digital procedure from designing to construction, complex geographical forms are being considered. Several of common programs are reduced. The required data were produced in 3D digital model and directly added to the complex. Having used new production methods, it exactly transferred to computer architectural form and in most parts, it is constructed automatically. In details of planning, developing and constructing, ball bearing steel structures and glass elements have been installed [5].

Image No. 11: plan of computer divisions of one of the shells, as it is known, no two parts has similar dimensions while their changes follow special discipline which is determined

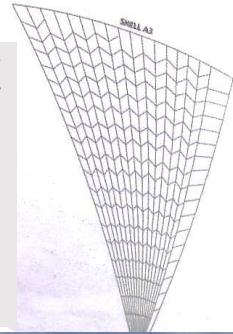


Image No. 12: layout of station and its glass shell



Image No. 13: manner of coating station with glass and its curvature



Image No. 14: form, body and glass ceiling of station

Dancing house in Prague (image No. 15)

Location: Czech Republic- Prague

Architect: Frank O. Gehry- Vlado Milunic

Date of designing and construction: 1992-1996

In architect's plan, a couple is seen as dancing who are at corner of two streets. Due to this similarity to building, it is named as "Ginger and Fred".



Image No. 15: layout of complex and manner of its putting



Image No. 16: view of the interior part of France restaurant of complex



Image No. 22: view of concrete structure progression of Beekman tower

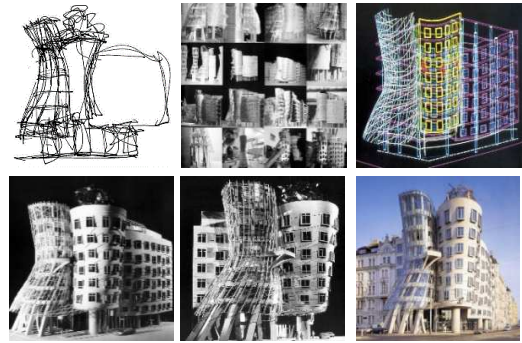


Image No. 18: primary sketch of building until final plan

Vaclav Havel, latest Czechoslovakia president and first Czech president proposed the construction of a residential complex in this land which remained as empty from its date of destruction to Vlado Melonki, architect on that country. This name is taken from an American dancer couple in a film for the same name by Federico Fellini 1986.

There is a France restaurant with river and city view in last floor of this building (image No. 16) which is as a hat for one of two dancer couples (image No. 17). It seems that building wall is folded under a pressure from above and windows are prolapses (image No. 18).

Beekman tower (image No. 19)

location: New York

Architect: Frank Gehry Architectural Group LLP

Year of Designing and Constructing: 2006-2010

Beekman tower is design by Frank Gehry in 867-foot height and 75-floor and it is the tallest residential tower of New York (image No. 20) and it is put in a block which is covered by four main streets of city and is located in south of Brooklyn Bridge (image No. 21).



Image No. 19: total layout from site and area of Beekman tower



Image No. 20: view of complex height and shell in it



Image No. 21: view of materials and area of Beekman tower

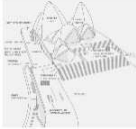
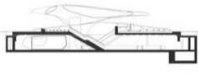
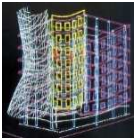

This concrete tower is made of reinforced concrete which is made at that place. The concrete of floors are supported via flat concrete pillars and several cutting walls (image No. 22)

Foundation of this building is excavated in vicinity of Metro tunnel in 5 to 6-foot depth and candle tensile in 18-inch diameter. Systems of residing against earthquakes and lateral winds are constructed by cutting wall around major core of building.

There are walls in 6, 38 and 76 mechanical floors which are involved with building pillars; these walls are put for minimizing the effect of mechanical equipment's function .

From among the architectural case studies (opera in Sydney, station in Edinburg and dancer's house in Prague and Beekman tower) which were studied, and analyzed, we can draw their results in table No. 2:

Table No. 2: results from studied, analyzed case studies (source: editor, 2014)

Item	Constructor's Name	Architect's Name	Year of Construction	Image Explanations	Using Digital Architecture	Results
1	Opera in Sydney	Jørn Utzon	1973		Computer modelling Shell Glass cover of building	Constructing and executing designed parts
2	Station in Edinburg	Zaha Hadid	2004		Glass cover design having thickness and curve	Making glasses with designed thickness and curve
3	Dancers House in Praha	Vlado Melonki And Frank Grehy	1996		Folding design of building wall under pressure	Building twist and curvature of volume and windows
4	Beekman Tower	Frank Grehy	2010		Fabric-shaped façade design Designing mechanical floors resistant against earthquake and lateral winds	Using mechanical walls for minimizing the function of mechanical equipments

2. Conclusion

Digital architecture is tangibly changing the designing and construction procedures. Harmonizing design, analysis and construction about digital technologies, architects, engineers and builders find a new opportunity for playing a role as main constructor and creator and combine separate guidelines from architecture, engineering and construction in a common and borderless form.

Nowadays we can display all assumed details of a plan in advance upon using digital space which was almost impossible in past.

What is leaned from studying the effect and cause of digital design process on quality of architectural spaces is that bilateral and dynamic relationship between parts can causes more maturity and development of design work.

Digital design process adds to creativity and strength of mind of the designer and causes that designer's mind act more dynamic and precise than before and increases the architect's mental archive related to diversity and multiplicity of architectural ideas and structures.

At the end, digital architectural design works has high precision and increase progress, representation and imaging in architecture.

Appreciation

This paper is taken from Master's thesis of first editor entitled as "architectural design of research- scientific park of Tabriz astronomy focusing on effective urban identity which is doing in Islamic Azad University, East Azerbaijan Science and Research Technology (2015).

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