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Framework for Utilizing of 3D Modeling and Virtualization Program in the Rehabilitation of Historic Areas Process

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***Abstract*: Recently, scientific research efforts have been directed towards studying the rehabilitation of historical areas and buildings by utilizing 3D programs with their various applications, in addition to merging data from the area or historical buildings and visualizing it with the help of three-dimensional (3D) applications. These efforts have resulted in the development of new techniques for restoring and preserving historical buildings, which have been proven to be more effective than traditional methods. The use of 3D programs has also allowed for better planning and management of restoration projects. The main objective of the research was to set a framework through which 3d modeling and virtualization programs are used in the different phases of rehabilitation of historic areas. in addition to constructing a heretical proposition for the relation between 3D modeling usage and urban rehabilitation phases. The study aims to provide insights into the potential benefits of incorporating 3D modeling and virtualization programs into the urban rehabilitation process. A questionnaire is conducted to ask urban heritage professionals about the best modeling and virtualization programs used in historic rehabilitation projects and their benefits at different phases. The results showed a frame work of selected programs used in the rehabilitation of historic areas process as a method for enhancing rehabilitation.**

***Keywords*: GIS, BIM, CAD, Urban rehabilitation.**

1. Introduction

Most of the time the ages of historic areas extend to ages exceed the age of the designers and dwellers of these buildings. When working on the rehabilitation process. It is necessary to provide all the information and maps about the area and historical building's details in terms of the horizontal projections, sections, constructional status, and other of the area are considered necessary and important steps before starting any processes whether restoration or preserving. It is assumed at the state level that there are documentation and preservation of all the architectural, urban, and historical items. The documentation is done by drawings and detailed descriptions with pictures according to the architectural, urban, and historical values of these areas [1].

Some experts found that urban rehabilitation projects in Egypt may lack adequate coverage of the essential design aspects [2]. The advent of 3D technologies has transformed the reconstruction and acquisition of data for cultural heritage establishments. In this age of rapid advancement of 3D data acquisition, VR and Augmented Reality (AR), and 3d modeling and visualization programs, numerous ways of presenting heritage areas have been used for different purposes [3].

3D modeling and virtualization programs may help designers visualize and interact with design alternatives, large urban data sets, and 3D information more effectively, thus correcting this problem [4]. However, there is a limited understanding of the impact that these programs may have on the quality of the rehabilitation process and consequently hesitation about the appropriate programs for their usage [5].

The research focused on the study of the process of rehabilitation of historic areas and its different phases and the study of 3d modeling and virtualization programs.

2. Urban Rehabilitation

Rehabilitation is a crucial process that helps to preserve historic buildings and urban areas, ensuring their continued existence for future generations [6]. It involves the careful restoration and adaptive reuse of these structures to meet the needs of modern society while retaining their historical significance. Rehabilitation policy is one of the policies dealt with in historical areas and buildings through a range of policies, which are as follows: rehabilitation, restoration, conservation, and reuse. This policy aims to improve the area as a whole and raise its economic and social scale. On the other hand, upgrading public utilities, infrastructure, and roadways to integrate historical and contemporary places in cities [7].

On an urban scale, rehabilitation policy tries to restore a built-up area's activities and functions to a realistic level. This could be accompanied by modifications in the area's use, occupancy, and traffic patterns to provide the necessary policies and costs for the area to serve a citywide role [8]. Rehabilitation policy can also include efforts to improve the physical appearance of a built-up area, such as through the renovation of buildings or the creation of public spaces, to attract more

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residents and businesses and promote economic growth. Additionally, community engagement and participation can be crucial in ensuring that rehabilitation efforts are tailored to the specific needs and desires of residents [9].

3. Urban Rehabilitation Phases

The main objective of the rehabilitation process is to preserve the historical and cultural significance of a site while also making it functional and relevant to modern needs. This involves careful consideration of design, materials, and construction techniques to ensure that the rehabilitation is sustainable and respects the original character of the site [10]. The urban rehabilitation process is a cycle that depends on the sequence from one phase to another, represented in the following, as shown in Fig. 1.

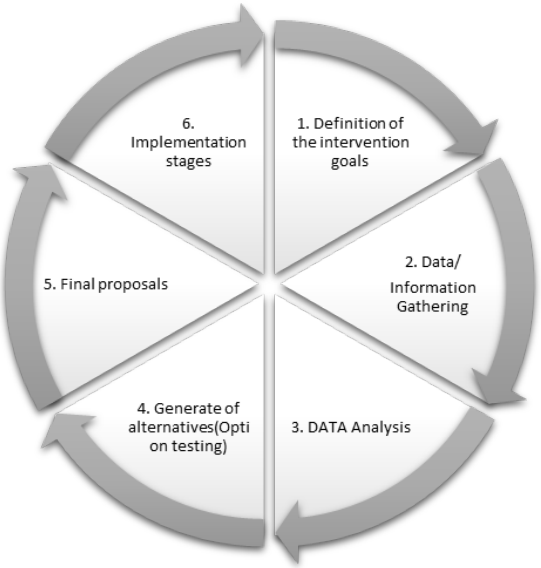

Fig. 1. Urban rehabilitation by researcher

A. Definition of the Intervention Goals

Defining intervention goals is the first step for urban rehabilitation. These goals must consider preserving and valuing the historic area [11], encouraging and stimulating economic activity, and meeting the requirements of the residents.

B. Data/Information Gathering

The information gathering phase includes new information needs such as mapping/cartography, surveys, geophysical surveys, building registration, photographs (normal, corrected, etc.), detailed inventories, database development, physical (visual) surveys, written surveys, Or oral of various kinds, interviews, oral history, commissioned studies and in-depth research (such as comparative studies) [12]. Understanding the physical form of the site's immediate surroundings and the history that shaped them helps the design team create a new development that enhances local character and distinction. It also identifies existing elements that are detrimental to this identity and may provide opportunities for adaptation or replacement.

The information related to this process is as follows [7]:

- Environmental, economic, and social data.
- Boundaries and physical features: Locating the sideroads/railways/waterways cycleways/footpaths-development plan- - open spaces, etc.
- Architectural or archaeological drawings of historical buildings.
- Aerial photographs.
- Applicable heritage and planning legislation
- Details of Indigenous/traditional ownership
- Other planning instruments relevant to the site: Land-use plans - Zoning plans - Infrastructure schemes-Local, regional, and national planning and development activities - Mineral and other extraction plans, environmental protection plans, and infrastructure development.

C. Data Analysis

The Analysis of the Current Situation is an important step in any regeneration project. However, while diagnosis is necessary, it is not always enough to motivate decisions. It is crucial to follow up on the analysis with a clear plan of action and implementation strategies. This will ensure that the project moves forward and achieves its intended goals. it includes [13]:

- graphical techniques for presenting data and statistical information - graphs, bar charts, pie charts, etc. conceptual diagrams illustrating ways of thinking and planning.
- opportunities and constraints.
- SWOT analysis (strengths, weaknesses, opportunities, and threats).

D. Generate Alternatives (Option Testing)

Continuity in providing solutions is an important stage in project development [14]. The set of alternatives must be presented continuously to ensure useful and reliable advice and review.

E. Final Proposals

The final proposal will serve as a comprehensive guide for the project and provide a clear visual representation of the proposed design. It will also be a useful tool for communicating the design to stakeholders and obtaining the necessary approvals. Also includes a master plan, axonometric maps and plans, elevation, section design code drawings, before and after sketches, and photo montage images [15]. Some details may need to be measurable from the plans, such as development plot sizes, heights of buildings, footpaths, cycleways, road and street types, density, nodes, land use, phasing plans, and active frontages.

F. Implementation Stages

The rehabilitation of a historic area can require years or more of planning, fundraising, and construction. However, the preservation of a city's cultural heritage is crucial for maintaining its identity and attracting tourism. since it covers many sites and their related owners. Residents in very

dilapidated buildings are expropriated, and the buildings are demolished and rebuilt, in general, by a public firm [16]. Other buildings are rejuvenated, after an agreement between the owners and an official co-investor organization. The municipality improves living conditions (through landscaping or the creation of public spaces).

4. Classification of 3D Programs Used in the Urban Rehabilitation Process

The development of 3D software has changed how data is gathered and rebuilt for cultural heritage institutions. Numerous methods of presenting heritage areas have been employed for various purposes in this age of rapid advancement in 3D data acquisition, VR, and 3D modeling and visualization programs.

Programs that use 3D modeling and virtualization could improve designers' ability to interact with 3D information, large urban data sets, and design alternatives. The programs are divided into types, as shown in Fig. 2.

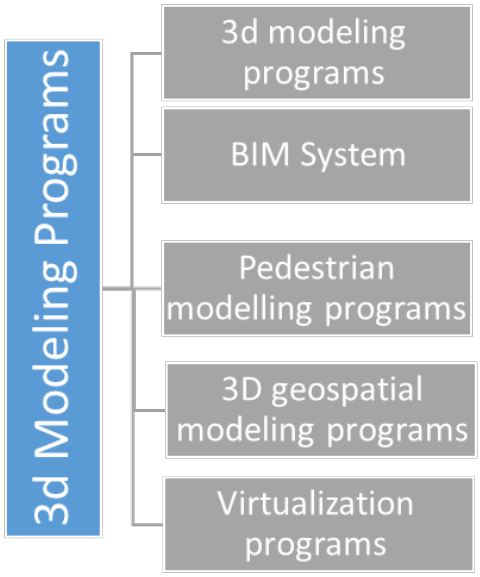

Fig. 2. Classification of 3d programs used in the urban rehabilitation process by researcher

A. 3D Modeling Programs

3D modeling is the process of creating a conceptual model that represents a three-dimensional object. A three-dimensional mathematical representation (in X, Y, and Z) of any three-dimensional object is created using a set of points in 3D space that are connected by various geometric data such as lines and curved surfaces [17]. This process is commonly known as 3D modeling and is widely used in various industries such as architecture, engineering, and entertainment to create visual representations of objects or environments. The resulting 3D models can be manipulated and viewed from different angles to provide a better understanding of the object's structure and design.

The first advancements in the history of 3D modeling came when the first commercially available CAD or Computer Aided Design systems started coming out in the 1960s.

Computer-Aided Design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design [18]. It is the application of computer software for drawing two-dimensional (2D) designs of development schemes, layout plans, master plans, regional plans, and building and facilities designs, including 3D modeling. Autodesk is a leading CAD software. manufacturer and the notable products are AutoCAD and 3Dmax.

There are different types of Autodesk CAD software; Freecad- Maya- Citycad-Blender.

B. Building Information Modelling System

Building Information Modeling (BIM) is a digital representation of the physical and functional characteristics of a facility [19]. Building Information Modelling (BIM) is an intelligent 3D model-based process that equips architecture, engineering, and construction professionals with the insight and tools to plan, design, construct, and manage buildings and infrastructure. The traditional building design was largely reliant upon two-dimensional technical drawings (plans, elevations, sections, etc.).

BIM's goal is to provide a common structure for information sharing that can be used by all agents in the design process and construction, as well as the facility management after a building is constructed and occupied [20].

There are different types of Programs; Archicad – Sketchup – Revit - Lumion - Rhinoceros 3D - Bentley Architecture-Infraworks.

C. Pedestrian Modeling Programs

Pedestrian modeling programs can either be a 2D or 3D application used to model the movement or flow of pedestrians within a given space and environment. A pedestrian model provides estimated values for the number of people walking within a given urban area or even a whole city [21].

There are different types of programs; DepthmapX, Bentley (LEGION & Open Building), SimWalk, PTVviswalk, and Massmotion.

D. 3D Geospatial Programs

Geospatial analysis software allows companies to analyze the locations, relationships, attributes, and proximities in geospatial data to extract insights using geographical modeling. It utilizes geographic coordinates (latitude, longitude, and elevation) to place a reference data point at a specific geographic location [22].

1) Geographic Information Systems (GIS)

Geographic Information Systems is a system designed to capture, store, manipulate, analyze, manage, and present spatial geographic data in 2D form [23].

There are different types of programs; ARC GIS Desktop-ARC GIS PRO- QGIS - city engine

2) Satellite imagery mapping software

Satellite mapping software uses images taken from the government, NASA, or business-owned satellites. These images are far more detailed than traditional map images and even aerial images y [24].

This makes maps created with satellite images ideal for projects that need to showcase geographic landforms, such as

mountain ranges and crevices, and landmarks like buildings, roads, and highways.

There are different types of programs; Google Earth - Worldview from Nasa - Maptitude Mapping

E. Virtualization Programs

Virtualization is a conceptual model of a virtual infrastructure that is commonly used in cloud computing [25]. It allows multiple virtual machines to run on a single physical machine, which maximizes resource utilization and enables easy management of the virtual environment.

There are different types of programs; Unity- Augeo-Unreal Engine

5. Framework for Utilizing of 3D Modeling and Virtualization Program in the Rehabilitation of Historic Areas Process

The study examines the possibility of proposing a framework through which to use the aforementioned programs in the process of rehabilitation of historical areas to save effort and improve the quality of outputs related to historic areas. The framework divides the rehabilitation phases into three levels as shown in Fig. 3.

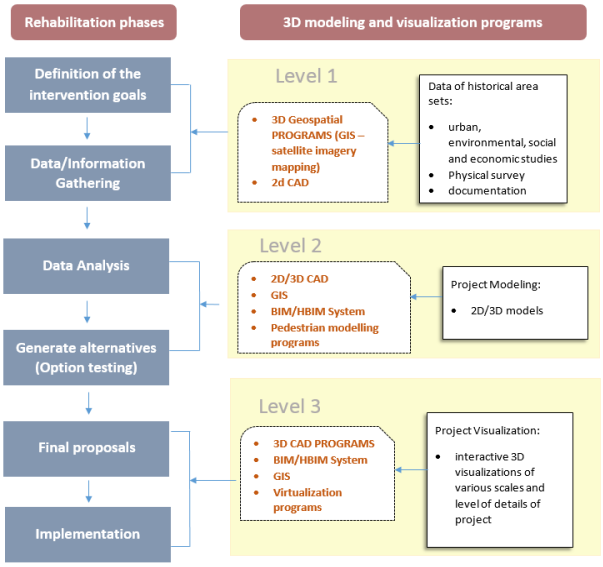

Fig. 3. Utilizing 3D modeling and virtualization programs in rehabilitation phases by researcher

Level 1 (definition of the intervention goals and data/ information gathering)

In phases of the definition of the intervention goals and data/information gathering, the data required is data of historic area sets:

- Urban, environmental, social, and economic studies
- Physical survey
- Documentation

Therefore, preferred using 3D Geospatial PROGRAMS (GIS and satellite imagery mapping) and cad programs, for the following benefits:

- GIS system provides an information base for the historic area and documentation of the historic building, the notable products are ArcGIS PRO.
- With the use of satellite technology data on the natural environment could be collected with ease.
- Survey of the existing state of urban fabric (drawing geometric drawings of horizontal falls, interfaces, and sectors) using AutoCAD software, clearly identifying all buildings and open spaces and showing various deputies through measurements of the height of corridor facades and building surfaces.

Level 2 (data analysis and Generating alternatives)

In phases of data analysis and Generating alternatives (option testing)s, the required data is swot analysis and Project alternatives Modeling(2D/3D models), therefore preferred using 2D/3D CAD, GIS, BIM/HBIM Systems, and Pedestrian modeling programs, for the following benefits:

- BIM/HBIM is used as an analysis tool to create information-rich, digital models consisting of streets, buildings, water supply, parks, and other infrastructure and generate alternatives, the notable products are Revit.
- GIS systems are used for geospatial data analysis, design, and computations on land information and socioeconomic attributes of an area, one notable products are ArcGIS PRO.
- Pedestrian modeling programs are used to model the movement or flow of pedestrians within a given space and environment, the notable products are Simwalk.
- 2D/3D CAD used for 2d and 3d visualization of design alternatives.

Level 3 (Final proposals and implementation)

In the phases of Final proposals and implementation, the required data is Project Virtualization (interactive 3D virtualizations of various scales and levels of details of the project) therefore preferred using 3D CAD PROGRAMS, BIM/HBIM Systems, and GIS).

- BIM models are then visualized and analyzed to assess the proposed development's efficacy and impact, and BIM technologies' role in coming up with detailed design drawings.
- 3D visualization for rehabilitation parts of the historic area by 3D CAD programs like 3Dmax.
- 3D GIS is 3D modeling software for creating massive, interactive, and immersive urban environments in less time than with traditional modeling techniques like Cityengine.
- Virtualization programs are helpful to present proposed urban rehabilitation in intuitive and interactive ways.

6. Questionnaire and Interviews

The objective of the questionnaire is:

Knowledge of the best 3D modeling and virtualization programs used in historic rehabilitation projects and their benefits at different phases.

Participants: A total of almost seventy-five specialists (34 architects and 41 urban planners) participated in this

questionnaire. These experts were asked to answer a series of targeted questions concerning the contribution of the 3D modeling programs in the rehabilitation of historic areas phases.

7. Results

A questionnaire is divided into four parts:

A. PART 1: Evaluation of experts' knowledge and experience of 3d programs and the extent of their use in their daily work

In this part, the research will compile and summarize the most common answers of the participants in the interview and also analyze the in-line questionnaire results. Regarding the question of how frequently professionals use 3D software in their daily work. Use Frequency and Levels of Experience are compared to examine whether experienced users take advantage of 3D software more often than less experienced users. It is obvious that in the expert/experienced groups, 26% of the respondents use 3D software often/a lot. However, in novice/new user groups, 56% of the respondents use 3D software often/a lot frequently. The results show that less experienced users would adopt 3D software more often than more experienced users. Among the nine 3D programs examined in the survey, respondents suggested that AutoCAD, ArcGIS, REVIT, 3D Max, and Google Earth are the most experienced in.

B. PART 2: Role of 3D modeling and virtualization programs in the rehabilitation of historic areas

1) Data Collection and Analysis Phase

- *Buildings and surrounding area*

From the result, it turns out that the programs used in data collection about buildings information and historic area maps were AutoCAD, google earth, and ArcGIS Pro as shown in Fig. 4.

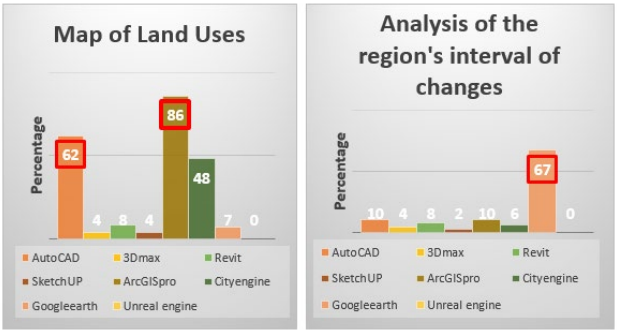

Fig. 4. Chart of data collection about buildings information and historic area maps by researcher

- *Data analysis*

The most programs used in Data analysis (site analysis) were AutoCAD, Revit, google earth, and ArcGIS Pro. The most programs used in Data analysis (environmental data) was Revit, however, the most programs used in Data analysis (social and economic data) were ArcGIS as shown in Fig. 5.

2) Design Phase and Alternatives Development

The most programs used in Alternatives Development were AutoCAD, Revit, 3DMAX, and Cityengine as shown in Fig. 7. The most programs used in Design Phase were AutoCAD, Revit, 3DMAX, ArcGIS PRO, and Cityengine. The design phase is to Design proposed work for the restoration and rehabilitation of buildings, streets, and assembly areas, and 3d visualization of the area. When mentioning virtualization, the most programs used were city engine and unreal engines shown in Fig. 6.

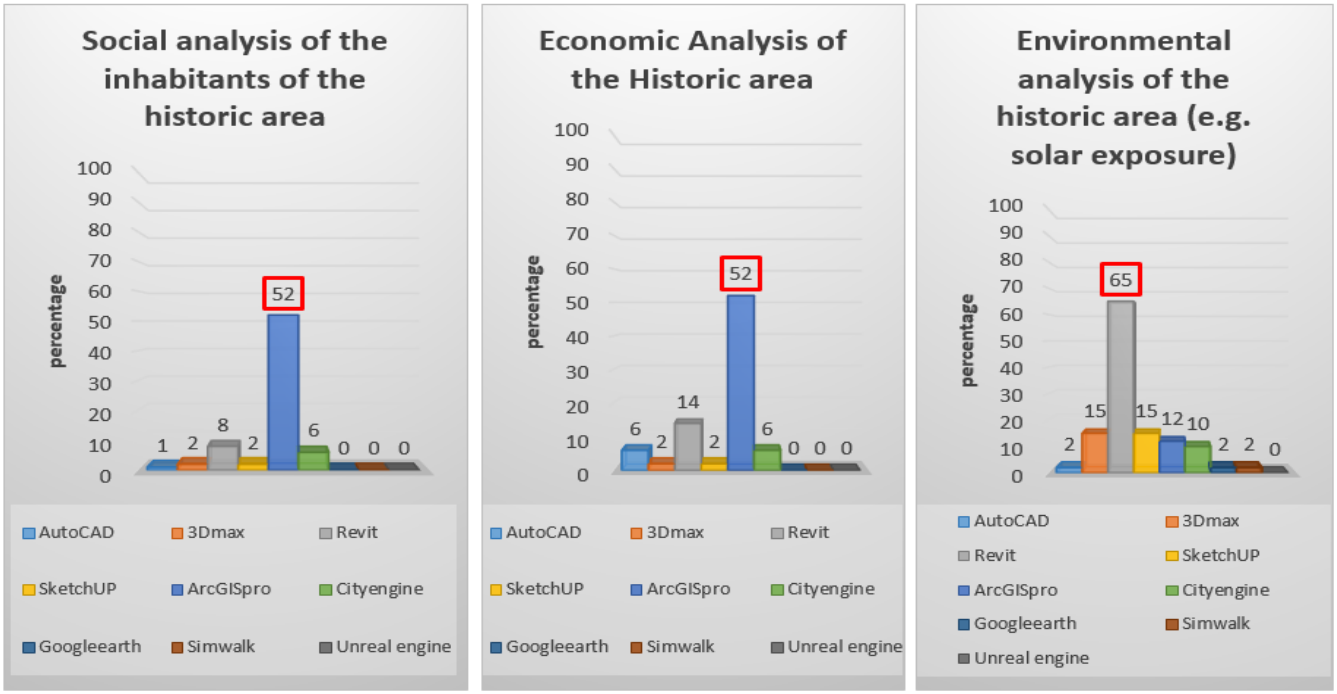

Fig. 5. Chart of data analysis (social, environmental and economic data) by researcher

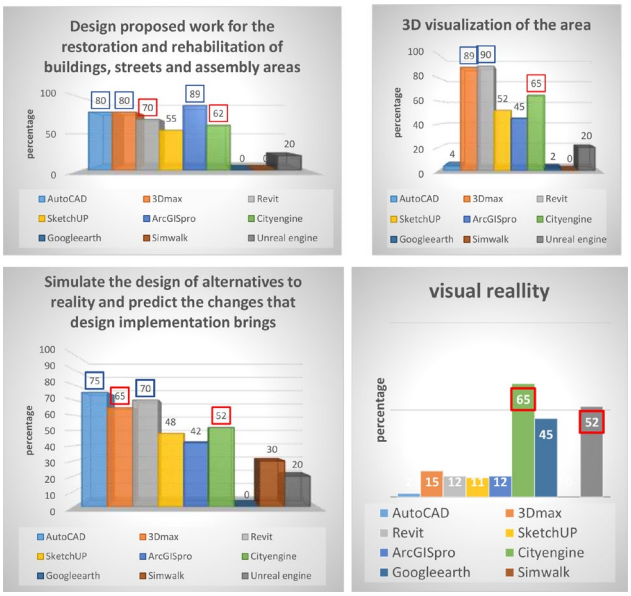

Fig. 6. Chart of using 3D programs in design phase by researcher

C. PART 3: Building information modeling programs (BIM) and their role in historic rehabilitation projects

This part discusses the awareness of Building information modeling programs through inquiring about the opinion of specialists on the importance of using (BIM). the results showed that Revit is the most used program as shown in Fig. 7.

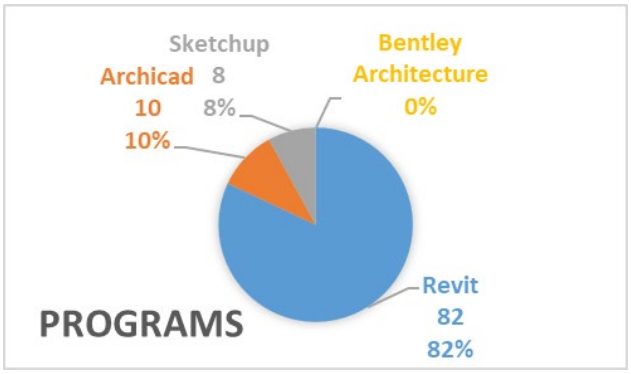

Fig. 7. The most used program in BIM system by researcher

D. PART 4: Modern orientation towards the use of virtual reality programs that help in the process of rehabilitation of historical areas

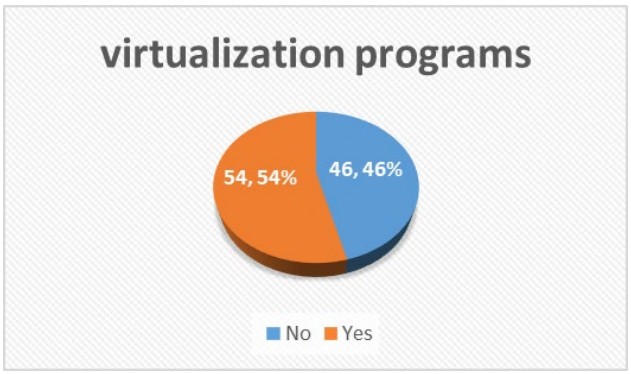

Fig. 8. Chart of virtualization programs by researcher

This part discusses the awareness of virtualization programs through inquiring about the opinion of specialists on the importance of using virtualization programs. the results showed that importance of using virtualization programs as shown in Fig. 8.

8. Conclusion

Application of 3D modeling is a boost to the urban heritage professionals as it offered a varied range of opportunities in project design and implementation. The time-saving, energy, accuracy, data storage, and management capability make the whole process facilitate effective job delivery.

A majority of respondents think that they can benefit from the use of 3D software in communicating with clients and the general public, creating detailed area representation, and easily receiving feedback and revising the model accordingly compared to traditional physical models. Other advantages such as animation and ease of transporting are also notable. professionals do express a desire to use more 3D virtualization programs in urban rehabilitation programs in the future.

However, several constraints on the future growth of 3D visualization software applications have also been identified. It remains complex and dependent on tech-savvy staff or the retention of costly outside consultants for 3D virtualization services.

This paper indicates that through theoretical study and questionnaire results, Generalize the use of the proposed theoretical framework to help save time and effort and improve the quality of outputs related to the historic area at different phases of rehabilitation. It is necessary to increase awareness of the importance of recognizing virtual reality and pedestrian modeling programs.

This paper recommended that Universities can prepare graduates with 3D programs skills to enter city planning departments as supported fellows to assist the department with 3D software training and adoption. Fellowships, funded by philanthropic foundations, software manufacturers, and professional firms, are both bridge career positions for new professionals and talent enhancements for planning departments.

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