# Virtual Reality as a Tool in Architectural Design Process

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**Abstract—**Virtual reality (VR) is a technology that enables users to interact with a computer-simulated environment, an actual environment that is imitated or truly an environment that exists only in imagination. The latest virtual reality environment generally presents a visual experience, displayed on a computer screen or via a stereo couple viewer, but some simulations include additional sensing information, such as sound through speakers or headphones. The emergence of virtual reality technology is pushing new changes in the field of design. Virtual reality in this case can reduce the many miss-communications that occur between the planner and the user when compared to using 2D media. The method used by discussing the phenomenon of virtual technology effects that are beneficial to the design process, by comparing the results of the real design embodied the idea of the initial idea. Where the comparison between the design results built from the designer's intuition compared with the results of virtual reality simulation test. Object of study used in the form of function of residential building to know suit owner desire which poured in the form of design and reality of field. Keywords: Maya Reality, Visualization, Design Process

## 1. Introduction

Utilizing the tools of graphic modern technology in architectural design has a much better design results as well as accelerating the design process. This paper will discuss how the use of technology aids can simplify and accelerate the process of designing the building. VR technology is a tool that can not only be used in the process of architecture design but can be as a medium to explain the physical implementation in the field. This technology is able to translate the design drawings into visuals that are easy to understand by the layman or most. Practitioner has difficulty to translate or realizing an image on paper into a real form. With the help of virtual reality, architect can explain a design through virtual reality media. In order to produce a design which is appropriate to the needs of clients, the use of the VR technology can be explored to facilitate the designer in translating the results of the design. The results of this paper are also expected to help the development of architecture, especially in the field of technological progress.

## 2. Discussion Methods

A qualitative method conduct by comparing the results between initial ideas, design process and the results of the implementation on an object of a house design which have been built to the design quality, accuracy and speed of design process with a case or project to be visualized.

### *2.1. Theory*

The literature study consists of main theories and supporting theories as well as the fact-based design theory and case study comparison. Virtual Reality is a technology that can visualize an idea or condition to become real through the process of computerization where the user can feel the real situation with the idea that has been made in 3D. With Virtual Reality (hereinafter referred to as VR) human needs can be realized with minimal cost at a maximum result. The existence of VR is very helpful for architects to estimate the shape and lay out of buildings in accordance with the reality. VR is very closely related to VRML (Virtual Reality Modeling Language) which is a computer format that explains the 3-dimensional objects static and dynamic and multimedia objects through hyperlinks such as text, sound, images, and movies. To use VRML files a user (user) requires a special VRML browser (in addition to an internet connection and a web browser. The development experienced by VR is not only from the many fields that can apply it, but also the tools used in Virtual Reality. Formerly the tools used to run the VR are only 3: Glove (Glove), Headset and Speaker, and Walker (sensory tool for foot movement). But as time passes, with the many changes that exist, more and more tools are used to run VRs such as: Head Mounted Displays, Head Trackers, Motion Trackers, Data Gloves, 3D

Controllers, Force Feedback / Haptics, Stereoscopic Displays, VR Domes, VR Simulators, VR Software / Kits, VR Therapy, and VR Wear. Of course the usage of the VR support tools is highly dependent on the usefulness of the VR in a field. How the virtual reality system works, Users (users) immediately see the images that are dynamic through headset and speaker devices that produce a sound similar to reality. The user movement can be monitored with the glove and walker devices by the system, and the system gives the appropriate reaction so that the user feels as if he can feel a situation like a real, both physically and psychologically.

*2.2. Virtual-Reality and its Applications*

The term "Virtual-Reality" refers to a world that believes to be experienced through our sensory skills, but not physically present in the actual world. In other words, VR is the thing to create a replacement for an actual space, event, object or environment that humans accept as real or true. VR is about creating substitutes for real-world objects, events or environments that are acceptable to humans as real or true. The terms "virtual environments", "artificial environments" and "synthetic environments" are often discussed (S. C-Y. Lu, et.al. 1999). "A VR experience can provide the immersion and psychological presence Immersion refers to the extent to which a user is isolated from the real world" (Gutierrez et al., 2008). Augmented Reality (AR) is a variation of VR. AR is similar to VR in the sense that both use virtual computer-generated data. Viraltual Reality tries to produce a complete environment, simulation or synthetic condition, which surrounds or submerges the subject. AR differs from virtual reality that does not try to block the surrounding real environment from the user. Instead the aim is to improve environmental conditions for a particular purpose (Mikko Sairio, 2001). The AR system component is similar to the VR system. It's just that the AR system is not intended to immerse users in a virtual environment but to supplement the real objects that computer graphics produce in the actual space so that the user seems to see the object in the real world. Illustrations of space system categories can be seen in Fig.

**Figure 1** Mixed reality movement
**Source :** B. MacIntyre, (2001)


**Figure 2** Component input to output VR
**Source :** B. MacIntyre, (2001)

The main components of the system hardware are VR engine or com-puter system, input device and output device. In general, the input device is responsible for interaction, output devices for immersive flavor and VR engine or computer following its software for control accuracy and synchronization of all virtual environments (Marzuryk et al, 1996; Burdea et al, 1994). Input devices are a means for users to interact with the virtual world. This device sends signals to the system about the user's actions, thereby giving the right reaction back to the user through the output device in real-time. These devices can be classified for example as tracking tools, point-inputs, bio-controllers and sound devices. Tracking devices are sometimes referred to as position sensors, used in tracking user positions. Examples of sensor types such as electromagnetic, ultrasonic, optical, mechanical and gyroscopic sensors, data gloves, nerve and muscle or bio controls. Examples of point-input tools are 3D mouse, joystick, pointer, and mechanical arm with visual display (BOOM). Nevertheless, other more sophisticated devices are also used, such as interactive gloves and voice recognition devices such as those used on Nintendo Wii (video game consoles). In fact, the user's body movements can be tracked using a suit or a special outfit with a measuring angle device placed at a point or joint, or a contactless tracking device, involving the use of optical sensors, ultrasonic sounds, infrared emissions, or electromagnetic fields (Gutierrez et al., 2008 ). This real-time motion detector is used to capture the user's position and movement. So it allows users to interact with the virtual world intuitively using natural movements.

Input devices that provide style information, power or movement for the user is called a haptic device. The haptic technology presents various forms of motion sensing and force and strength and provides tactile feedback to the user. Through this device the user can interact with the virtual world

through hand gestures to touch, shift and capture virtual objects with a sensation that approaches the real thing. However, due to the many limitations of the haptic, users typically use more visual cues to help them overcome these obstacles. VR Engine or computer is data processing and storage. Real time, graphical display and image processing are some of the most important and time-consuming factors in the operation of VR systems so they must be selected according to the character of the application needs. The selection of VR Engine depends on the application field, the user, the input and output devices, the required immersive level and graphical output, since VR Engine is responsible for calculating and producing graphical models, object rendering, lighting, mapping, texturing, simulation and so on to be displayed in real-time. The computer as a VR Engine also handles interaction with the user and serves as an interface with both input and output devices.

The output device is a tool that receives feedback from VR Engine and presents it to the user through an appropriate output device to stimulate the senses. Some classifications of output devices based on the senses are: graphics (visual), audio (hearing), haptic (touch or style), smell and taste. Visual display is the most popular output in VR system while other types of display are complementary. The visual display is a device dedicated to the eyes of users who present the 3D world. There are six categories of visual display which each of them provides different immersive levels, desktop displays, head mounted displays (HMD), arm-mounted displays, single-screen displays, surround screen displays (CAVE, Panoramic screen) and volumetric displays (Shneiderman, 1998 ; Stuart, 1996). The output devices that are also popular in VR as well as input tools are interactive gloves, speakers, earphones and 3D glasses for stereo display. A stereoscopic visual display is used to present the virtual world in 3D. There are two types of stereoscopic rendering developed for the projection of images onto the screen ie passive and active. Active Stereoscopic requires shutter glasses. Each eye receives a separate image to give the impression of stereo vision. Stereoscopic passive use red/green glasses polarization. Two sets of images are projected simultaneously. Each eye receives a different image because each filter eyeglass lens comes out a set of images. This type of passive solution cannot be used on desktop displays (John N.W et al., 2001).

*2.3. Theory of design process*

In the traditional design process can be developed into a new design process that is based on pragmatic design. In praxis design that has ever experienced can add insight in the new design process.(Bryan Lawson, 1980). When making a decision of the overall need to design a COT building it is necessary to consider the "optimal solution" or "true needs" in connecting with the design space. It will be a solution which has considered all the needs in terms of architecture, structure and structure.

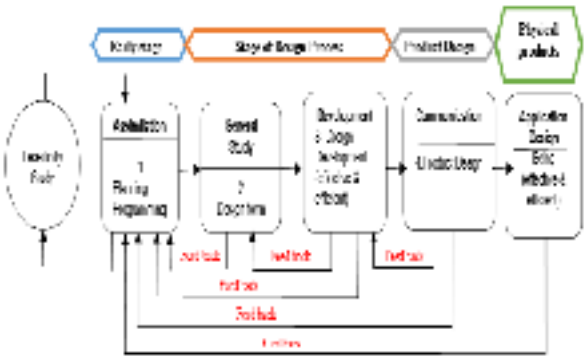

**Figure 3** Design Process
Source : Jones, Christoper, 1970

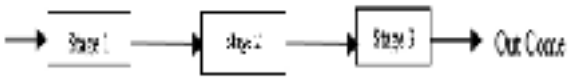


**Figure 4** Design process phasing Chart
**Source :** Lawson, Bryan, 1980

The design process is part of the development process that generally goes through certain stages. One of the stages is a conceptual stage, in which the form of design produced in the form of concepts. In the field of architecture there are actually many approaches to building design processes that are often used to help the discovery of design solutions that match the needs and expectations that have been determined. One of the well-known human-made physical development processes in architecture is the input-output process proposed by Benjamin Handler (1970). The input-output approach of Benjamin Handler is in principle the same as the design process offered by Bryan Lawson (1980). Principles of input output design process taking into account the effective and efficient aspects to be able to continue the process to produce a truly effective and efficient physical form.

In Design Methods J.C. Jones (1972) identifies the design process assessment as a material for methods that would improve the quality of the design, especially when the design method is associated with building function. Much of the sequence of activities in the field of this design method has been carried out in England, Scotland, Australia, Czechoslovakia, Poland and the United States. Pre-planned Strategies: Linear In a linear strategy, it is a strategy to undertake design actions in which the needs programs are clearly appropriate to the situation or circumstances required. The problem is to add the function needs according to the existing state or to modify the existing state with the addition. The result of the action is done to produce output of stand-alone output.

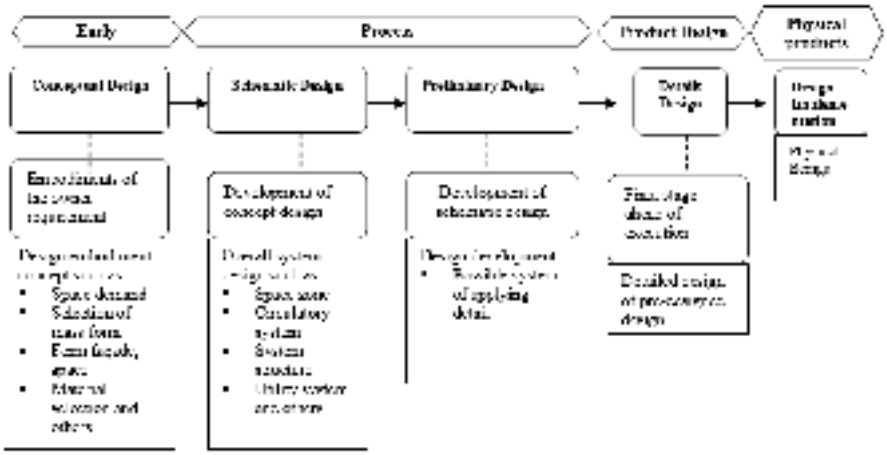

**Figure 5** Phase of Design Process Chart
**Source :** Jones, Christoper, 1970

Cyclic Strategy If the output or output at the beginning of the stage does not or has not given the appropriate results, then at the beginning of the repetition stage to check the extent to which the needs of the function has not met the criteria. And the feedback is done in several stages to produce the expected output in.

## 3. Data Analysis

*Case / Project (Home Stay)*

Idea of the initial design of the building according to the owner's input / user poured in the initial design sketches, either in the form of layouts and sketches in 3D look. In order to know the suitability of the initial idea, it needs to be assisted by existing VR tools used to visually explain the initial idea result of a residential building design.

*3.1. Virtual Reality*

The process of virtual reality work in incorporating the design of the building design, the designer needs a GPU toolkit

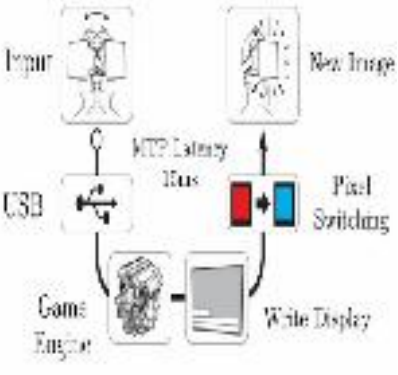


**Figure 6** Network image input system to VR **Source :** Daniel A. Guttentag, (2010)

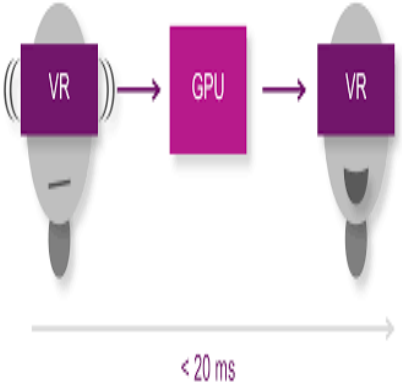


**Figure 7** Tool to get to VR.
**Source** : Daniel A. Guttentag, (2010)

**Figure 8** Human point of view in VR
**Source :** Thalmann, D. (2008)

Images or visual designs that have been made in 3D sketches incorporated into the system and connected into the machine and then the image into the VR. Required GPU support device to deliver design results into VR. The GPU can be either a computer or a smart phone. The result of the visual perspective depends on the movement of the user following the standard rage of the human senses so that the resulting atmosphere is similar to reality

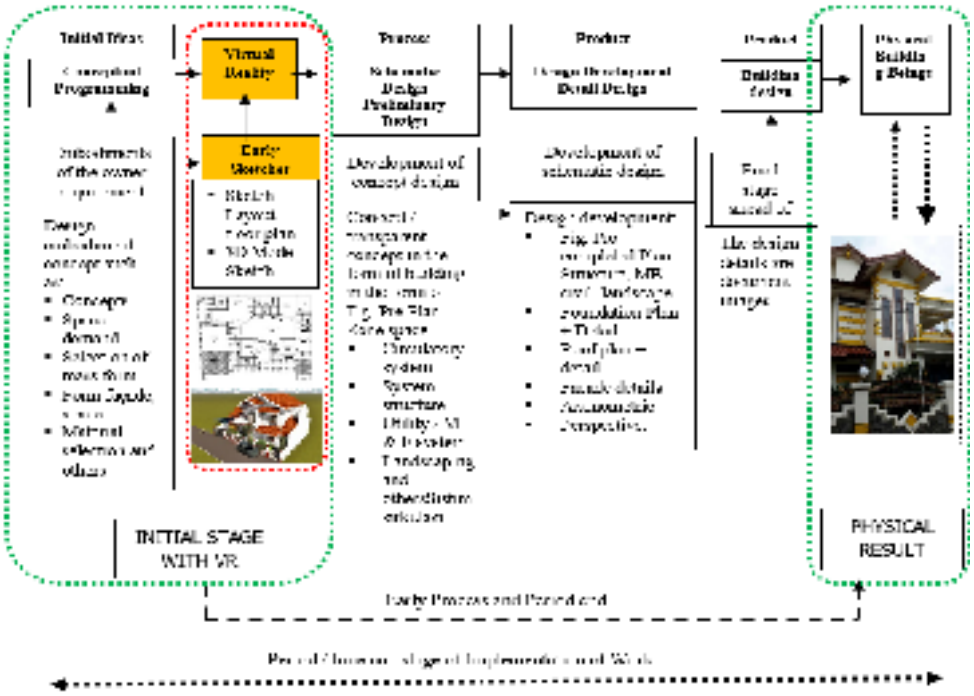


**Figure 9** Chart of planning phasing up to implementation
**Source :** compiler

Design process through several stages, namely from the beginning stage, stage schematic process, preliminary design, design development, product design and physical building. VR bias helps to bridge the initial process and ends in physical results in the field, because the three-stage process after the beginning is actually more focused on the implementation of the concept on the design as a whole. If the initial design can provide a bright spot for the owner a live planner to prove what has been described in the initial design executed in the physical form of the building. A building modelling can be done using the software in accordance with the designer's skill. The initial sketch process can be visualized by demonstrating the transformation of the initial idea form. The design development stage of the sketch is incorporated into virtual reality tools. In addition, this initial idea process can be seen with the simulation from various corners of the field both exterior and interior. The virtual results obtained by people who see the design in the VR will feel like the space is inside the building.

The object location at Jalan BKR –Lingkar Selatan, Bandung.


**Figure 10** Location Object

**Figure 11** Form Transformation Process
**Source :** compiler

The initial sketch process can be visualized by demonstrating the transformation of the initial idea form. The design development stage of the sketch is incorporated into virtual reality tools. Viewed from the diagram above, the design process with the use of VR tools can be a bridge connecting from the initial idea process to the process of schematic and preliminary design workmanship. The output is a sketch of layout and 3D model sketch. In this design process the method of applying design simulation using VR tools can assist the designer in communicating the ideas so that they can be understood. (fig. 12)

**Figure 12** Viewpoint from the right side of the site
**Source :** compiler

**Figure 13** Viewpoint from the left side of the site

Visualization of 3D imaging models from a VR perspective can show results that almost resemble when a room is built. Viewpoints can also be a more manageable as needed. Observation through virtual reality can help planners in assessing the proportion of the building whether it is in accordance with the designed or not. (fig. 13). By utilizing this VR technology, designers and assigners can see the design results freely, because users of this VR can move into the building that has been designed.

**Figure 14** Viewpoint of the main entrance
**Source :** compiler

The image in table 1 is a 2D planning drawing of the front view of the building and then the image is inserted into the VR tool. Inside the VR tool will be obtained a 3D image results that describe the shape and looks like in 2D images. This form will help an owner feel as if they are in the wake. The design results that have been viewed and understood will be implemented and produce a real result exactly as seen in the VR image will result in 3D building view visibility as shown in the VR real estate planning drawings in Table 1. From the comparative case of building design above, it can be

seen that using virtual reality design tools described to be more easily translated as evident from the results of real buildings can be similar to the planned building. (table 1).

**Table 1.** Comparation

| *Image of 2D planning* | *Image of 2D planning Image Planning VR* | *Real Building Results* |
|---|---|---|
|  |  |  |

## 4. Conclusion

From the results of simulation analysis that has been done above can be concluded that the technology of virtual reality tools can translate visually the design results become more easily understood by the assignor / client to feel the atmosphere of space directly. Although still in the form of 3D images, the experience of space can be felt because the user VR / client as if located in the designed buildings. In the design process the use of VR tools can be done at the design proposal stage until the gradual construction of the building to facilitate the process of design and implementation of the field.

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