VIRTUAL REALITY IN ARCHITECTURE
PROJECT REPORT

A DISSERTATION REPORT

(Code AR 8015)

Submitted by

J . SREENIDHI

Reg. No: 311318251137

In partial fulfillment for the award of the degree of

BACHELOR OF ARCHITECTURE

in

ARCHITECTURE

MEASI ACADEMY OF ARCHITECTURE: CHENNAI – 14

ANNA UNIVERSITY: CHENNAI – 600 025

JUNE 2022

ANNA UNIVERSITY: CHENNAI – 600 025

BONAFIDE CERTIFICATE

Certified that this project report "**VIRTUAL REALITY IN ARCHITECTURE**" is the Bonafide work of SREENIDHI who carried out the project work under my supervision.

Prof. M.R. MOHAMED KHALID

PRINCIPAL

MEASI Academy of Architecture,

87,Peters Road, Royapettah,

Chennai-600014

Ar. H.RIYAZ MOHAMED

SUPERVISOR

MEASI Academy of Architecture

87,Peters Road, Royapettah,

Chennai-600014

INTERNAL EXAMINER

EXTERNAL EXAMNIER

ACKNOWLEGEMENT

A dissertation cannot be completed without the help of the many people who contributed directly or indirectly through constructive criticism in the evolution of this whole work . It would have not been able to achieve this without their help through a period of education , enlightenment and pleasure .

First and foremost , I would like to express my gratitude and appreciation to my dissertation guide AR . RIYAZ for his efforts and constant insights with keen pursuits . and AR JOSEPH for giving me a chance to work on this topic . Their support has enabled me to finish this dissertation project effectively .

I would also like to offer my sincere thanks to all the faculty , teaching and non-teaching staff of Measi academy of architecture for their assistance .

Thank you

Sreenidhi

VIII semester

311318251137

ABSTRACT

IMMERSING ARCHITECTURE BEFORE ARCHITECTURE THROUGH VIRTUAL REALITY

A BRIEF ABOUT THE PROJECT

The importance of the use of advanced technology, such as the popularity of virtual reality in the architectural space, is increasingly necessary. There is an ongoing need to put the use of this technology at the professional level.

Virtual reality (VR) refers to a computer-generated environment in which a person participates and determines the performance of the space.

The advantages of using this immersive experience is in the way they can be used early in the stages of thought and till the execution phase in order to further explore the relationships between different spaces, light, construction, and physical. The use of focused representation allows for the opportunity to quickly understand and comprehend these design elements, as opposed to just looking at a scale model or visual presentation. People who may not be associated with the work of a designer or architect may not be able to understand the relationship of space and scale if they look at a two-dimensional supply, however, the use of virtual reality is very common and can evoke positive responses in the same way physically. properties can.

This paper examines how VR is used in architecture. It is a process-driven study that enhances its extensive function as a cognitive function and research aimed at understanding the implications of understanding spaces in VR.

It concludes by identifying VR as an exciting new phenomenon, with its own set of rules, pros and cons very helpful to the industry. This approach therefore enhances user experience as it becomes a major part of interacting with the environment while designing.

TABLE OF CONTENTS :

LIST OF FIGURES

CHAPTER 1 – INTRODUCTION

RESEARCH QUESTION:

- What is the Role of VR in architecture in understanding spaces better?
- How to use VR to design effective solutions for presentation and communication?
- how is the complexity reduced in the design process and decision-making process?
- is VR more effective than 3d models and 2d drawings?

AIM:

This paper aims to understand the high-fidelity architectural visualisation that is significantly contributing to the design industry that is the effective utilisation of tools like virtual reality and its potential contribution in architecture is going to be the next great leap after the transition of manual to digital process..

OBJECTIVE:

- Judge the practicality of VR in architecture
- Applications of VR in architectural education
- How to effectively increase the communication between architect and his client with its impact

SCOPE AND LIMITATIONS:

The research will cover the implications and benefits and the potential of virtual reality in the use of architectural design.

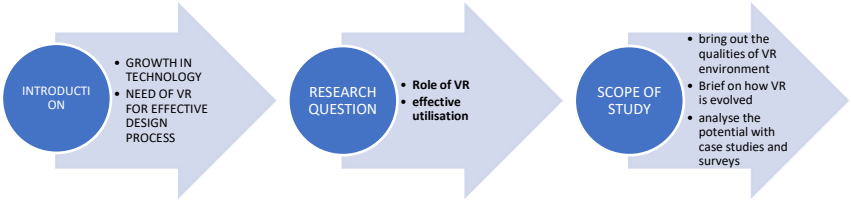
LIMITATIONS:

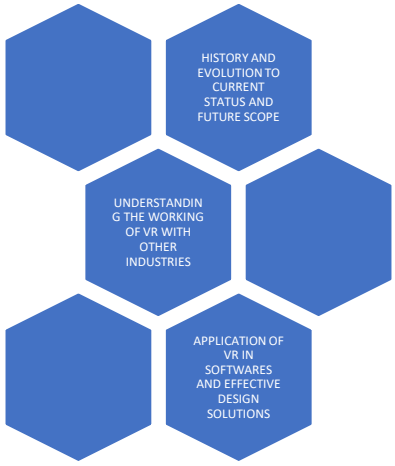
Paper will not be exploring solutions to induce VR into architectural field rather focus on analysing its potential and giving an immersive experience in design process. Paper doesn't involve the use of AR and only talks about role play of VR

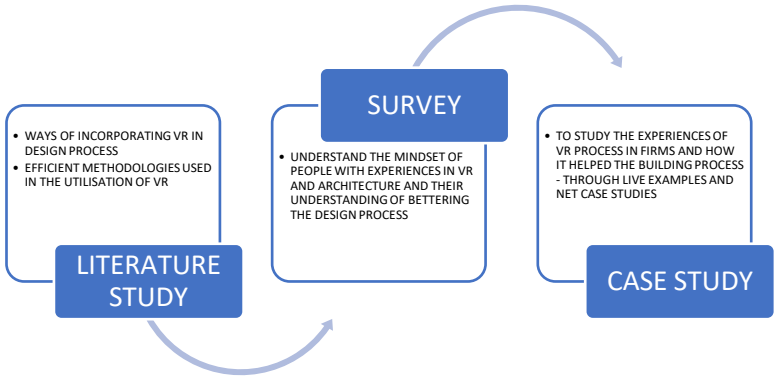
SCOPE:

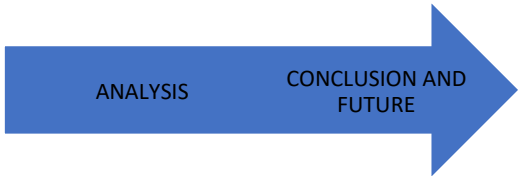
- Research and bring out the qualities of VR environment.
- Brief on how VR is evolved today and its existence in the professional field.
- Show the use of VR and how can it be fitted in architecture work.

METHODOLOGY









RESEARCH WORKFLOW CHART

CHAPTER 2- LITERATURE REVIEW

PURPOSE OF LITERATURE REVIEW :

The intention of the literature review is to provide with an overview of ideas and theories and significant literature. This research will be based on in-depth study of certain philosophies, concepts and theories that will address the issues and problem stated in this dissertation.

As a result , a literature review will comprise these issues that will be critically analysed and strengthen the appropriate precedents and case studies . The experiential aspects and tactile qualities that enhance a place are discussed in the theory of phenomenology. The natural environment will be investigated in relation to the qualities that affect design physically, mentally, efficiently. The relationship and understanding of the flow and uses to be analysed.

CATEGORISATION OF LITERATURE REVIEW :

Building connections between architecture, design , construction and spatial experiences through "VIRTUAL REALITY" is a notion that seeks to enhance the quality of the design environment that contribute to the physical design and allows the user and the designer to find a greater understanding of the surrounding .

It is important to understand and develop a link between architecture and Virtual reality as these will later make the the users experience more meaningful, flawless and effective with the invisible aspects of space identified. The development and justification of a framework beings to unite the both, moving more towards a holistic relationship identified.

- OVERVIEW OF VR – BACKGROUND STUDY
- COMPLEXITIES AND UNIQUENESS IN PROJECTS
- OVERVIEW OF VR IN ARCHITECTURE
- CURRENT PRACTICES WITH CASE STUDIES

OVERVIEW OF VIRTUAL REALITY – BACKGROUND STUDY :

VIRTUAL REALITY (VR) is a three-dimensional realm created by computers and software simulations that recreates an artificial environment that the user believes and accepts as real. Virtual reality can be experienced physically via devices such as customized helmets with screens built in, sensor gloves, or other sensorial electronics that control one of the five human senses.

Virtual Reality (VR) is a new computer technology that allows for comprehensive 3D simulations. It is a perfect fit for architectural work because it entails the complete specification of buildings before they are built. Despite the profession's long history and experience in the use of 2D-plans for building design, the rising complexity of projects and societal engagement necessitates the use of better representational media. Virtual Reality's technological promise, on the other hand, necessitates a number of advanced software and hardware breakthroughs. It is based on 3D modelling techniques that are now included in the majority of architectural drawing software, as well as various tools for rendering, animation, and panoramic views that create visual authenticity. Other characteristics, like as interactivity and a sense of immersion, are more sophisticated, costly, and under development. These necessitate intricate configurations and uncomfortable use of stereoscopic helmets, 3D pointers, and trackers. The most complex Virtual-Reality systems, such as CAVEs, require a lot of gear, a lot of building area, and a lot of user constraints. Nonetheless, a number of developers are working on user-friendly Virtual Reality approaches, and there have been a number of early experiences with architectural walk-throughs that have demonstrated benefits in design communication and development. After that, we might see a rise in the usage of virtual reality in architecture.

Virtual reality provides a more realistic experience. It is particularly effective during the conceptual stage, as it aids the architect in comprehending essential project elements and delivering a more realistic message. Individuals can interact with and explore the virtual reality as if it were genuine. By wearing headsets, the user can experience a 3D environment, which allows for a greater knowledge of objects in space, material perception, and more precise calculations.

Immersive vs. Non-Immersive Virtual Reality: What's the Difference?

The design process benefited from both immersive and non-immersive VR. With a tracking HMD and wand, immersive VR provided the designer with a better sense of

space and the ability to observe the design from the inside. The designer was able to analyse details and connections more naturally with an easy-to-control viewpoint at the scale of a person within the structure. Later in the design process, this came in handy because the designer was able to see minor defects in the model. Non-immersive VR, which used a monitor and a space ball, provided higher resolution and frame rates, which became increasingly important as the model became more sophisticated. The non-immersion allowed for easier and faster viewpoint manipulation. This was excellent for travelling around the outside of the building during presentation flythroughs.

Level of Specification:

The designer was able to perceive spatial features of the design that were not obvious with other design media after a key level of detail was portrayed in VR. VR as a design tool appeared to be a viable, although not unique, technique of representation before the model's complexity reached a certain degree. As the model's level of detail (colour, transparency, and geometric complexity) increased, real-time simulations became more valuable as a design tool. To keep the frame rate at an acceptable level, the level of detail had to be kept in mind. The difficulty posed by this contradiction necessitated the creation of a second, more detailed model as well as the designer's ability to abstract the models. Despite the development of more sophisticated geometry engines, it is unlikely that we will ever be pleased with the level of detail that can be replicated in real time. This could highlight the need for new ways to present complicated geometry to the viewer, both in terms of rendering algorithms and database layout. Complex objects must be displayed with a particular level of abstraction, which necessitates the development of new algorithms. Designers and modelers must currently decide which features of a design are most important to its character, and which polygons should be removed. This is a time-consuming and subjective procedure that relies on the designer's or modeler's abilities and intuitions. If there were algorithms to simplify geometry while maintaining its aesthetic essence, designing in digital media would be more helpful. The database could be organized in a "hypergeometry" style in addition to such abstraction in the display of complex geometry. Higher levels of detail could be provided only when a specific portion of a design is being analysed using such a style. A designer in a room, for example, might select a single object or feature from the database and be supplied with additional information (geometric and alphabetic) on that condition of the design. Such a "hyper-geometry" approach would be in line with how architects are used to presenting their designs, which includes general views as well as blow-ups and studies of common and unusual elements.

The Medium's Immediacy :

There was no instant response from the walk-throughs because the simulations were done weekly after exporting and translating files from the CAD database. Although virtual reality was effective for analysing the three-dimensional model, it was not useful for designing the product. Instead, the design was created using a process that included drawing, three-dimensional CAD modelling, and real-time simulations. Digital models may be used by designers during the development of design ideas if they have access to a comprehensive modelling package. A Critique of Virtual Reality in the Architectural Design Process might be created in the same manner as physical models are built to improve the perception of a design created through sketching. It's certainly possible that VR may replace "modelling" in the same way that CAD is replacing (or has replaced) "drafting" if the VR medium can provide the same quick feedback as CAD or more traditional design mediums. Two-dimensional media can only portray three-dimensional space to a limited extent. The impression of three-dimensional space is enhanced by three-dimensional media. VR can provide designers with a digital design medium that gives them rapid, direct, and intuitive control over their three-dimensional design. Other design media would be supplemented, not replaced, by a comprehensive, three-dimensional world-building toolkit that equals the sophistication of today's CAD software. Before VR can considerably improve the design process, such software is desperately needed.

Tool for Making Presentations:

The films of the walk-throughs used to exhibit this project allowed design reviewers to see the design as it progressed. Physical models were no longer required, and they clarified what was not apparent in CAD designs. The response from design juries was overwhelmingly positive, far beyond expectations. The taped "walk-throughs" were often highly convincing to design critics, and they represented that the design would produce a very believable building. This speaks a lot about VR as a presenting tool: it allows professionals and design critics, not simply clients and laypeople, to picture one's design objectives more clearly than traditional forms of representation. Several design reviewers and jury members, on the other hand, stated that they would have gotten more out of the experience if they could walk or fly through the design themselves rather than relying on views from a certain path flown for the presentation. They couldn't employ a VR system because of the high expense and difficulty of transporting it to the presentation location. Even if the system had been made available to them, walking through the design individually would have taken too long, and it

would have been hard to debate the design with others who hadn't seen the simulation in three dimensions. Clearly, the emergence of a low-cost, multiple-participant VR system could solve thisproblem.

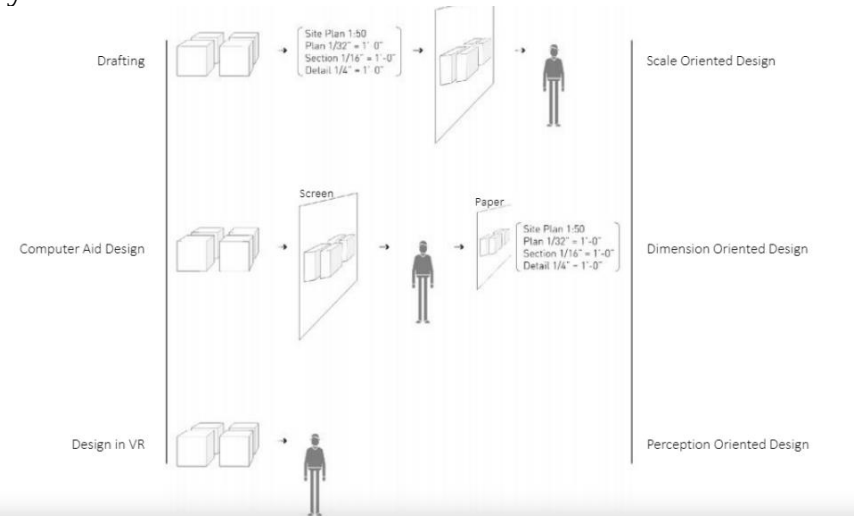


FIGURE 3: IMAGE: DIFFERENCE OF VR AND TRADITIONAL WORKING SPACE WITH RESPECT SCALE(source:augmented reality Research for Architecture and Design)

Experiencing a project spatially rather than abstractly also allows for the designer to better understand the physical experience of the building, which allows for them to make more accurate assessments of the comfort level of the space, by judging things such as lighting or spatial characteristics, before presenting their designs to clients.

FIGURE 4: IMAGE: TYPES OF VIRTUAL REALITY(source:augmented reality Research for Architecture and Design)

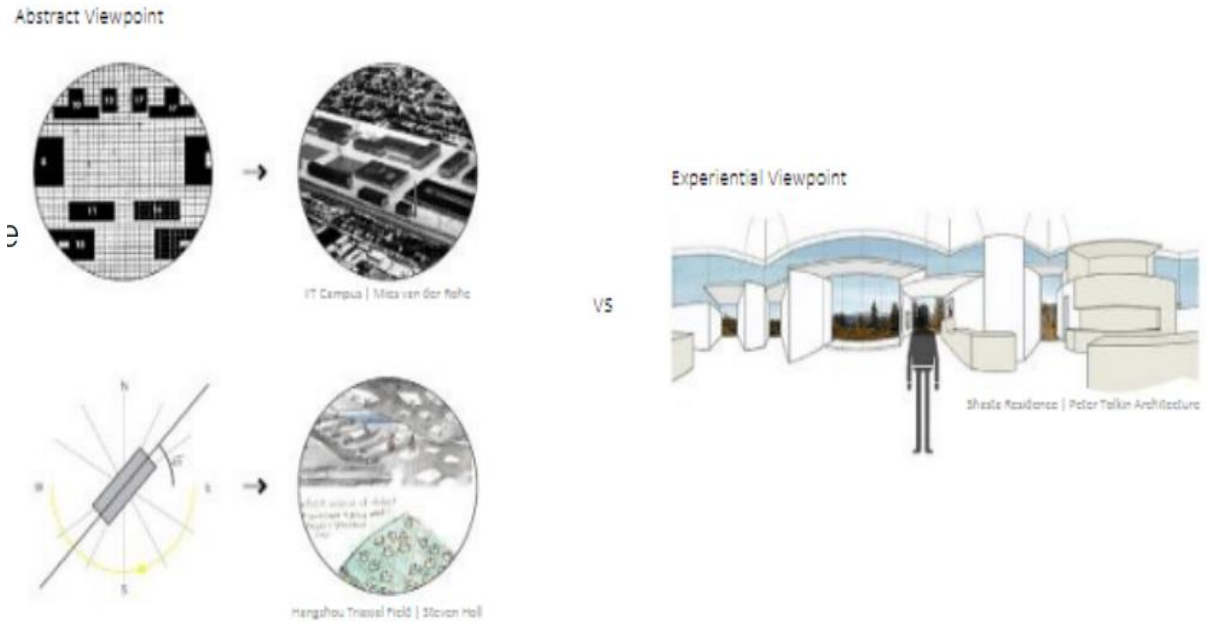


FIGURE 5: IMAGE : DIFFERENT VIEWPOINTS OF THE VIEWERS(source:augmented reality Research for Architecture and Design)

COMPLEXITIES AND UNIQUENESS IN PROJECTS

understanding how VR is implemented in the design process with the help of case studies

OVERVIEW OF VR IN ARCHITECTURE

development of virtual reality VR system components benefits and potential of VR in architecture types of VR increasing immersivity and interactivity through VR

CURRENT PRACTICES WITH CASE STUDIES

challenges in design decision process early design decision and design review engagement of end users and stake holders in project

1. CASE STUDY 1: Explains how VR is used during the design review and the design approval for a railway tunnel projects in Norway.
2. CASE STUDY 2: Explains how VR implemented as a decision-making tool in pelletizing plant in Sweden.
3. CASE STUDY 3: Explains how VR used for understanding the spatial arrangements in university project in Brazil.

IMPORTANCE OF DESIGN DECISION:

Decisions are an important part of the construction industry at every stage. As there are a few phases involved from the concept phase to project delivery, the decision-making process tends to be complicated. In the context of such decisions, it is advisable to use “different support mechanisms”. High project costs, poor quality, delays and inadequate production are the result of poor planning and management, according to the conclusions of a few studies previously conducted . The tasks followed in the construction process are design, development, integration, and construction. Even though some aspects may differ greatly from one project to another, the tasks and decisions are essentially the same. “The decision-making process is crucial to the success of any construction project. Wrong decisions can be costly in terms of time, quality, cost and relationships”. This means that in a real construction environment, making informed decisions rather than relying on self-understanding and assumption is important. Architectural practitioners and stakeholders must be trained in the decision-making process to come up with a better design.

So there is a visible lack of the right decision-making platform which creates a huge change . people view VR as a tool that brings value to design updates, conveys the purpose of design and improves the efficiency of meetings. Compared to standard offers and standard drawings, the tool allows users to navigate the structure and understand its beauty in a more malleable manner. Using virtual reality to visualise a space or the building allows individuals to quickly navigate with current design features and programs. Creating a common level of familiarity allows people to collectively view the model and enhances interdisciplinary interactions, expertise and technical interactions. It has been noted that the review of 20 projects including VR has raised serious questions that have raised unexpected design issues, which could be easily seen in renders or traditional models. Hence there is a explicit need to bring about effective frameworks for the effective implementation of decision-making theories. The VR concept brings, in fact, a set of new possibilities and solution with its impressive technological capability . This technology allows professionals to find a virtual environment, providing a VR capture environment. Their aim will be to see if the adoption of VR can influence employees' perceptions of how to use it to make construction decisions.

Complexities :

Recently, the size and complexity of the project has seen an enormous increase. Some of the things that add to the complexity of a project include timelines, unexpected domain conditions, structural problems and much more. In addition to the impact of the difficulty and its features, employees often face difficulties in understanding what is expected. A few studies have also shown that traditional project management tools

are lacking in dealing with project complexity. This clearly means that decision-making strategy contributes to resolving difficulties in working groups. So this study is focused on reducing the barriers to decision-making.

Uniqueness :

A study conducted by Nam and Tatum (1988) compares construction with the manufacturing industry on five factors: complexity, immobility, costliness, durability and continuous improvement. The authors identify these five elements as critical success factors for the successful working of the construction sector.

VR IN DESIGN DECISION :

If the project is complex like the ones that involves a work flow connecting different stakeholders and that's a huge project on track which takes time for a productive outcome , it is very difficult to maintain contact records and communication within the flow. This complex situation might lead to information inflow and a lost flow of information among participants. Loss of information in a traditional work program is often due to a lack of trust or inadequate communication tools. Two crucial factors can increase communication and remove technical and social barriers which includes increasing trust between affected stakeholders and increasing the confidence and credibility of data transactions that is the proper information about the space in this context . VR can close the communication gap between the design team and the client by producing a more accurate representation of the quality of design that can make a significant contribution to output assessment .

Looking at a case study that's been studied before , To support city planning decision makers, a team of researchers researched the possibility of integrating VR with the Geographic Information System (GIS). The goal from the study was to find out how VR and GIS can provide solutions and ideas to city planners and authorities in the Gaza Strip, Palestine. Provide new processes from existing tools that can support decision makers. The authors argue that using VR in urban planning can improve the way engineers, designers and decision-makers understand a project. They can get real-time design results in the project environment. They can deal with different situations and compare them in a short time. Researchers have used the case to prove the point of using VR via GIS. The study planned a railway line that would connect between several cities in the Gaza Strip. They built several models as alternatives to rail design without focusing on the details of the rail itself. Along with the case study, the researchers compiled a questionnaire of a group of designers, urban planners, and the responsibility for decision-making in the region. satisfaction of participants. For example, 90% of participants announced that a tool is useful to show or add an idea.

In addition, the question of decision-making using the traditional method compared to VR and GIS, 63% of participants indicated that they prefer VR with GIS rather than the standard method. The results highlight the potential for VR in urban planning and especially when integrated with GIS. It enhances the designer 's ability to express design ideas. When participants met the city model in VR, they could easily identify the city and become familiar with the streets and neighbourhoods. There were some participants who faced management issues and exploits within VE and some of them pointed out the need for training before implementing the program.

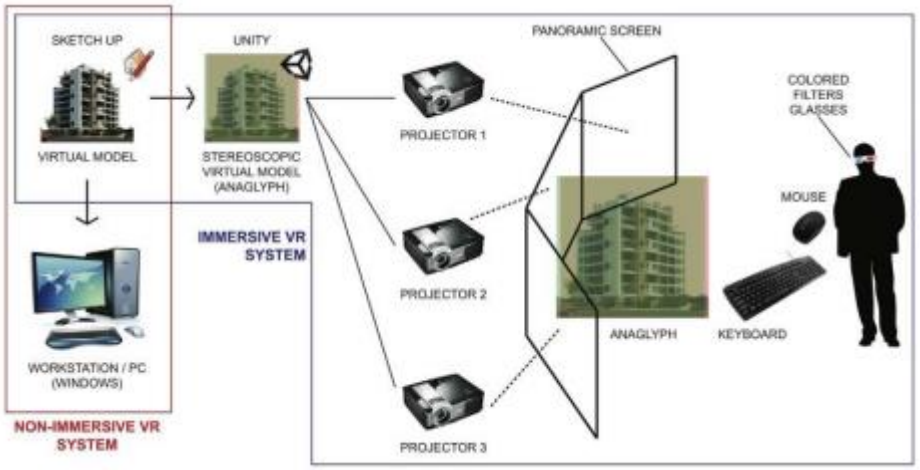


FIGURE 1: IMAGE: IMMERSIVE VR SYSTEM (source: virtualhandsofthearchitect_dondiman)

FIGURE 2 : IMAGE : NORMAL AND VR IMMERSIVE DESIGNING(source:google images)

WHERE WE ARE RIGHT NOW: TECHNOLOGICAL STATUS:

Virtual reality has made significant and rapid progress in the first fifteen years of the twenty-first century. The development of consumer virtual reality has been fueled by advances in computer technology and 3D graphics capabilities. Human computing tasks include depth sensing cameras, sensor suites, motion controllers, and natural human interfaces. Virtual reality, according to this technical definition, is a simulation technique that uses headsets and physical props like controllers and sensors to impose a realistic multi-projected environment on a user. VR stimulates and immerses a user in a rendered world by allowing them to look about, navigate, and interact with the artificial environment's components.

Virtual reality has previously only existed in the laboratory, primarily as a tool for research and development in the educational, medical, and rehabilitative domains. The introduction of accessible virtual reality to the public sphere in the last decade has sparked a surge of interest in the technology among designers, architects, and visualization specialists. Any room can be transformed into a virtual world into which a user can walk and experience the sensation of actually being there. As a result, virtual reality (VR) is increasingly regarded as a technology that will have a transformative impact on the way humans work, perceive entertainment, and convey ideas in the coming decade. VR may be used to realistically imagine any environment, regardless of whether or not the architectural space existing in the present, because it isolates the user from the physical world by commandeering sight. As a result, it is more broadly applicable to the entire spectrum of architectural **work.**

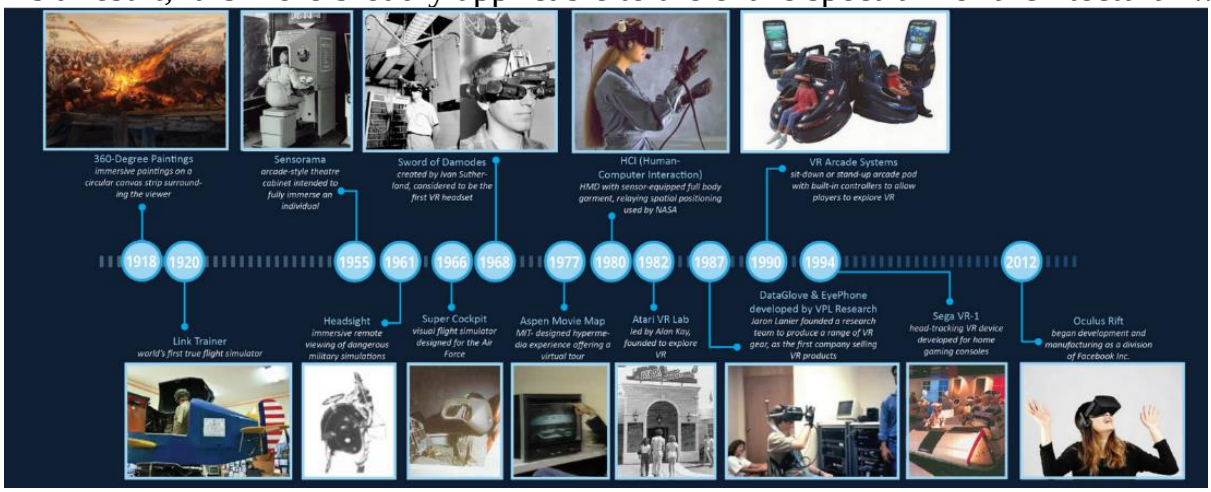


FIGURE 6 : IMAGE : TIMELINE OF VIRTUAL REALITY DEVELOPMENT (source: google images)

VIRTUAL WORLD :

IMMERSIVITY IN THE VIRTUAL WORLD: It is also critical for a good architecture visualization to ensure that the audience has a proper sensation of presence. It gives audiences additional opportunities to act as though they are in the real world, allowing them to develop a more realistic mental sense of imagined space. Virtual Reality is the only visualization media that can considerably improve the realistic effect of architectural visualization, turning it into a full immersion experience. It can assist architects, clients, and other architectural design participants in better understanding the design concept and making more informed decisions.

INTERACTIVITY: People's interactions with the physical world are interactive in nature.

This interactivity is a key aspect of the physical world's experience.

The audience can walk through the environment, rotate the viewpoint, open the door, move things, play videos, switch off the lights, and engage in a variety of other interactions in virtual reality.

SENSORY FEEDBACK: Virtual reality provides sensory feedback to the audience, which is superior to other traditional visualization technologies. 49 Visual feedback is the most common type of sensory feedback in architectural virtual reality. However, architects can use aural input to keep the audience engaged and provide a more realistic virtual experience. For opening the door or playing a video, the appropriate sound can be created. High-speed computers and an advanced interface are required for haptic, olfactory, and gustatory feedback

.Case Study 1 : Design Review And Approval Of Tunnel

Ulrike Tunnel is a part of a 500 km railway road between two big cities in Norway, Oslo and Bergen. The project’s main challenge was to construct the new tunnel without disturbing the trains flow in the old tunnel beside the commitment of the project time and budget . In the traditional design, the method of testing and approving the signalling system requires a long time after the signals are installed. Therefore, the design team implemented VR and combined it with the BIM model to enable the train operators to drive and test trains in the VE and before even the tunnel being built . The surrounding terrain environment was created using a drone and then combined with the VR model.

Improving the design process will reflect positively on the construction

- Using VR for simulating operation on infrastructure projects could facilitate and speed up design approval

• Design engineers could understand the infrastructure operation better when watching simulating the operation process

• Involving the operation team could help in enhancing the design and finding better alternatives

• The maintenance team could simulate infrastructure maintenance plan even before the project completion.

FIGURE 7 : IMAGE : : PICTURE FROM THE VR MODEL FOR THE DRIVER'S SIGHT. SOURCE: (VANNE, 2017)

CASE STUDY 2: DECISION MAKING IN MK3 PLANT, SWEDEN

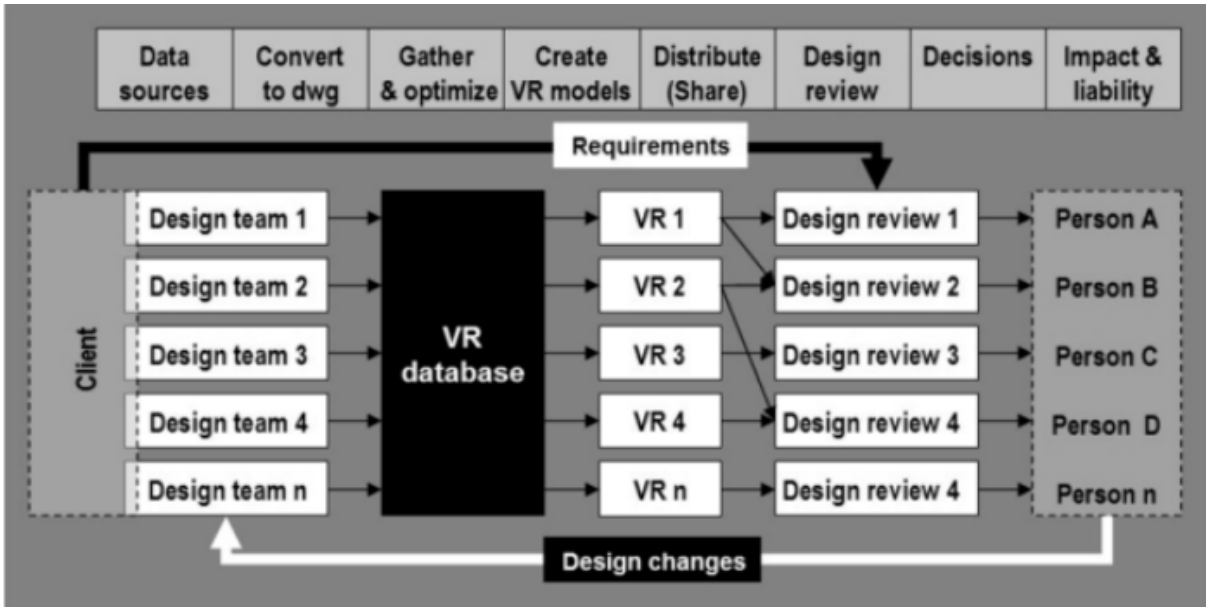


FIGURE 8 : IMAGE : : VR DATABASE WORKMODEL AND FLOW (source: Virtual Reality in the Architecture, Engineering and Construction Industry thesis paper)

In the north of Sweden, the Swedish mining company LKAB was planning to build a pelletizing plant called "MK3". The client's priority for the design and planning was the manufacturing process then the layout with the surroundings and finally the construction of the plant, which lead the project team to focus more on the manufacturing process as a priority than the real construction. Because of the complexity of the project and the need to meet the client's requirements, the contracting between all parties formed as Partnering and the project team used CVE in the design process. The CVE implemented directly from the beginning in the design process aiming for improving the communication between partners, reducing the risk, and achieving the goals of stakeholders. The project team produced different VR models for multiple reasons For instance, there were models for planning the spatial space, understanding the facility and machines inside, training the workers, and simulating the production process. Using VR models increased the understanding of information during communication. One example about the use of VR model during the design; sometimes a design team needed to take a decision quickly regarding the design, but the timetable was limited to consult the other teams, as an alternative they could use VR to see exactly the consequences of their design decision on the other discipline.

Access to correct and up-to-date information facilitates client's decision process and positively influences outcomes

- Efficient data exchanging tools such as VR can lead to precise earlier decisions

- Team working, sharing responsibility and trust within a CVE increase transparency and clarity

- Involving clients in daily design activities through VR models reduces the time needed for making decision.

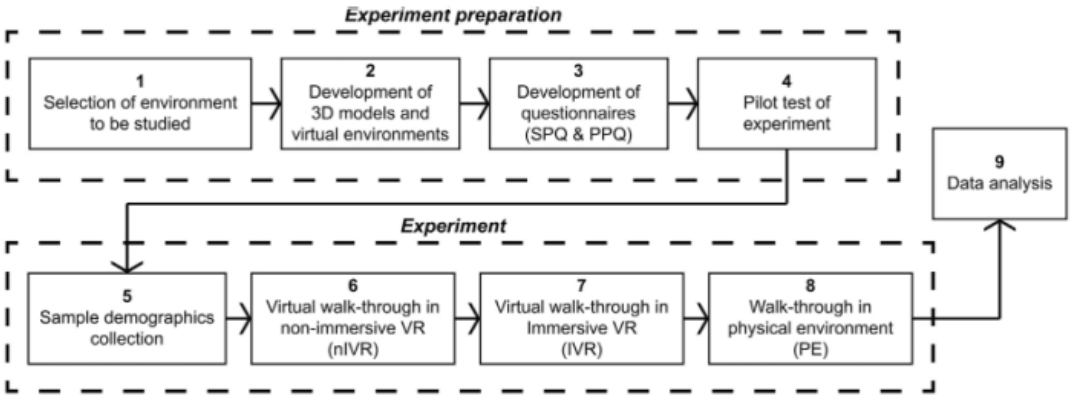


FIGURE 9 : IMAGE: PROCESS OF PRODUCING VR CONTENT THROUGH DIFFERENT METHODOLOGIES FLOW (source: Virtual Reality in the Architecture, Engineering and Construction Industry thesis paper)

CASE STUDY 3: SITE PLANNING FOR CAMPUS BUILDING IN CYPRUS

A group of researchers performed a case study in university building in Cyprus to check the benefits of VR in site planning. The main idea from the case study was to compare three different approaches for site planning; 2D drawing, 3D model, and VR model. After the selection of the site, the researchers proposed two different scenarios for planning logistics in the construction. The construction management of the project created the first scenario based on previous experience. For the second scenario, they did some modifications for site access, materials locations, number and location of cranes, waste location, site office, and site orientation. The building selected is approximately 9,000 square meters with a budget of $4.5 million and should complete within a tight schedule of 11 months. . After the selection of the site, the researchers proposed two different scenarios for planning logistics in the construction. The construction management of the project created the first scenario based on previous experience. For the second scenario, they did some modifications for site access, materials locations, number and location of cranes, waste location, site office, and site orientation.

FIGURE 10 : IMAGE : THE SELECTED CONSTRUCTION SITE. (source (muhammad;yitmen;alizaedhsaehi;& celik, 2019)

Creating the VR Models The researchers created different models for different scenarios with the help of Autodesk Revit, SketchUp, and Lumion software. Revit used for creating the structural model then the models exported to SketchUp. . Then the model exported to Lumion for final rendering, after that the model was ready for VR experience .

After analysing the answers of the questionnaires for the participants of this experiment, the researchers discovered that a 2D drawing in site planning is easy to understand and less time-consuming compared to the virtual environment. However, the participants believe that VR increased the understanding of the site planning, the ability to detect collisions, and predicting the site constraints through better evaluation of different scenarios . The researchers recommended that the construction managers have to practice more using the visualization tools, visualize better the site planning and increase the level of details for the site space

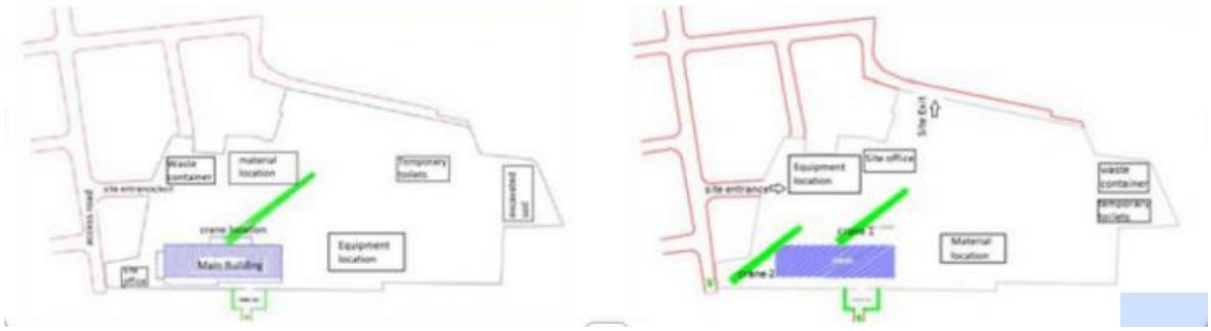


FIGURE 11 : IMAGE : COMPARISON OF 2D , 3D AND VIRTUAL REALITY PLANNING PROCESS(source: Virtual Reality in the Architecture, Engineering and Construction Industry thesis paper)

VR is more effective than 3D model and 2D drawings regarding planning the site components and placing materials

- VR is more effective than 3D model and 2D drawings regarding detection of future collisions of construction equipment and testing different site planning scenarios

- VR is difficult to use and handle compared to 2D drawings and 3D models, which means training needs to be considered when using VR.

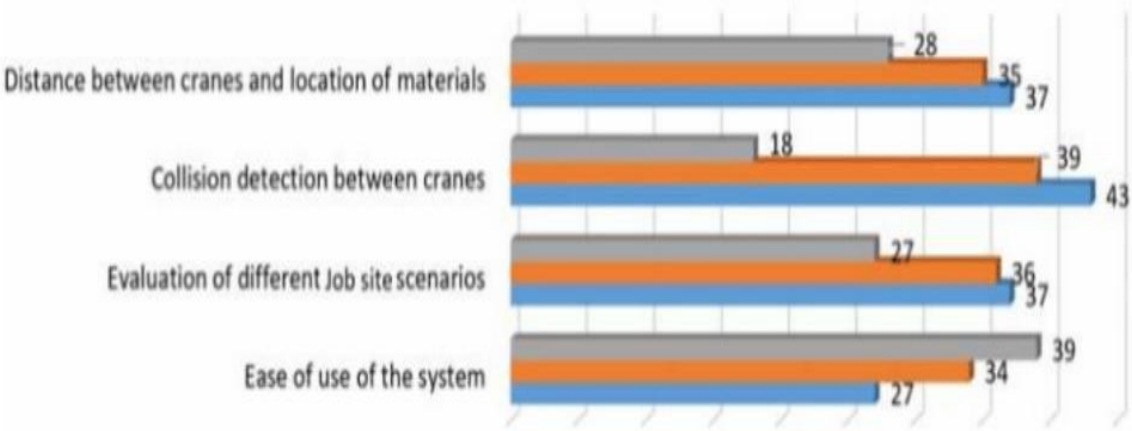


FIGURE 12 : IMAGE : COMPARISON OF 2D , 3D AND VIRTUAL REALITY PLANNING PROCESS(source: Virtual Reality in the Architecture, Engineering and Construction Industry thesis paper)

CHAPTER 3 – RESEARCH STUDY

Virtual reality in architecture can be supported by its immense attribute to the technological innovation shift and its helpfulness in the human designs and understanding qualities.

Methods adopted for data collection and its justification:

Research methods have been explored to provide the basis of collection and analysis of data which is necessary in satisfying the objective of the study . a systematic method of collecting and analysis of the information was done and established to recommend the issues inferred by the whole paper.

Various methods to obtain the data for research study:

Net referencing

Questionnaire

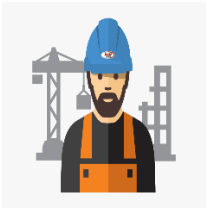
Papers written before

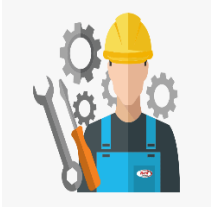
Participant observer

Library study

IDENTIFYING USER GROUP / PARTICIPANT GROUP:





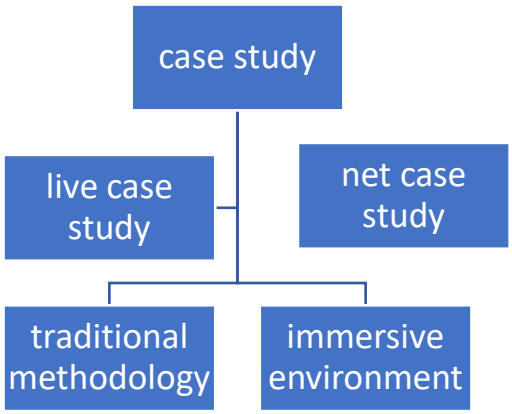


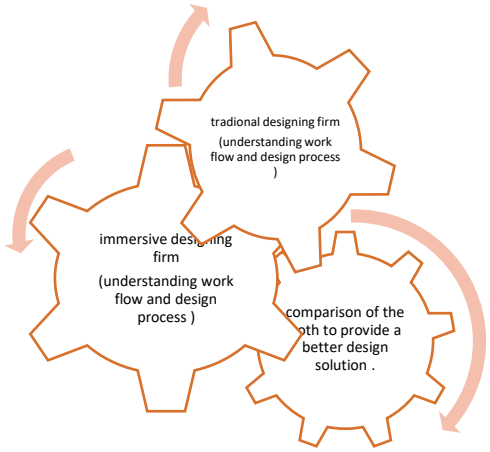
ARCHITECTS BUILDERS PROJECT MANAGERS ENGINEERS STAKE HOLDERS

DESCRIPTION OF THE DOCUMENTATION :

In order to compare the methods of the traditional work environment and the virtual reality induced work environment , both the type of work process were studied through live case studies of 2 chosen firms – walllab architects and LNT constructions . the documentation was done based on the design process that

was followed by each type of firm and whose methodology turned out to be better in terms of design output .





Collecting and Validation of Data :

The first phase of the experiment was data collection and validation. The main purpose of this phase was to measure the reliability of implementing VR in the construction site planning. The researchers used a sample comprising 6 professionals working in the construction industry. I selected participants from different specializations in construction such as construction management, design management, architectural design, and structural engineering who has experience in working with an architect who has worked with the virtual reality in their design process . The participants were from different positions such as BIM specialists, site supervisors, site engineers, architects, design managers, construction managers, and structural engineers. The participants were asked to assess, monitor, compare, and rate three different approaches for site planning 2D drawings, 3D model, and 3D in VR. The rating scale was from one (highly ineffective) and five (highly effective). The researchers categorized the overall rating of the participants as high if it was over 80%, medium if it was between 60-79% and low if it was less than 59%

QUESTIONNAIRE :

ROLE OF VIRTUAL REALITY IN ARCHITECTURE

NAME , JOB POSITION AND COMPANY :

LAKSHMI - HVAC CONSULTANT, L&T

Adithyan- VDC coordinator . L&T

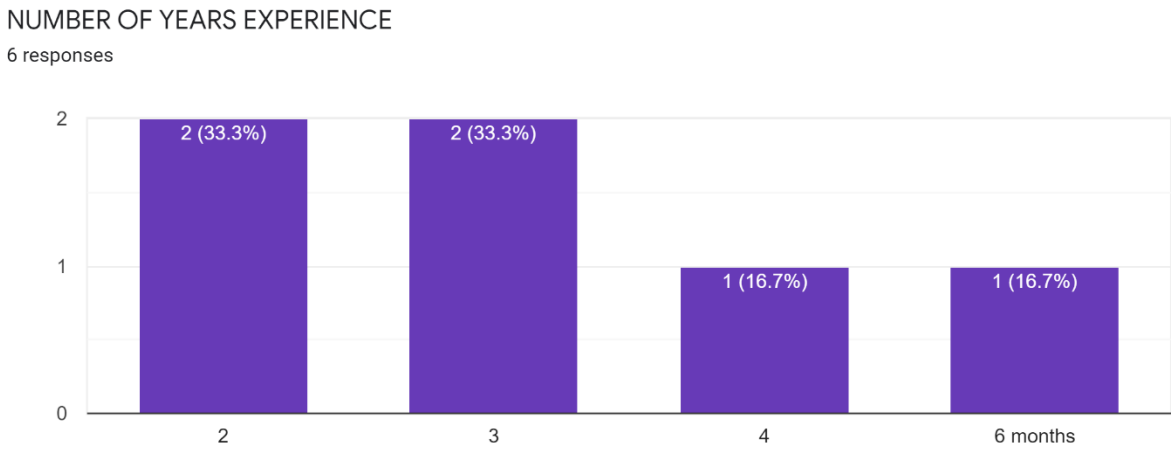
Jagadish Babu Baskar - Construction Analyst / Faithful Gould Inc.

Bharath Venkatachalam - Student assistant at Virtual Review Assist

Usama Kharodia - Intern- VRA

Rohan- Research Assistant, Design for Interaction @ UNStudio

NUMBER OF YEARS EXPERIENCE :



FOLLOWING THE BASIC UNDERSTANDING OF THE VR THROUGH THE STATEMENT QUESTION , THIS QUESTIONNAIRE IS DIVIDED INTO 3 STAGES OF DESIGN PROCESS AND THE EEFECT OF VR IN THESE STAGES

QUESTIONNAIRE :

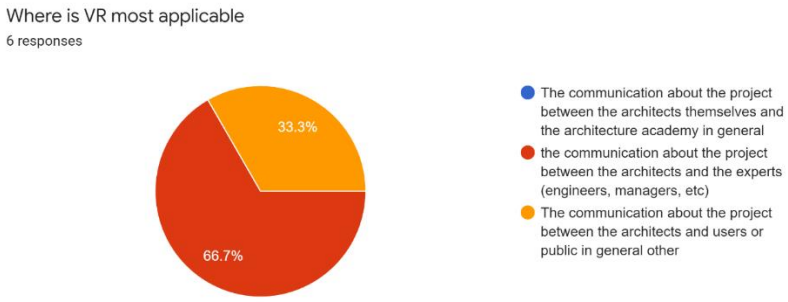
1 . HOW IMPORTANT IS VIRTUAL REALITY IN:

THE COMUNICATION OF THE PROJECT BETWEEN THE ARCHITECTS THEMSELVES AND THE ARCHITECTURE ACADEMY IN GENERAL

THE COMUNICATION OF THE PROJECT BETWEEN THE ARCHITECTS AND THE EXPERTS (ENGENEERS, MANAGERS, ETC)

THE COMUNICATION OF THE PROJECT BETWEEN THE ARCHITECTS AND USERS OR PUBLIC IN GENERAL OTHER

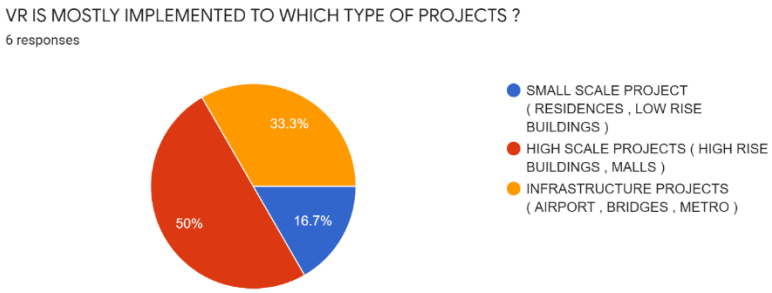
RESULTS :



2. VR IS MOSTLY IMPLEMENTED TO WHICH TYPE OF PROJECTS ?

- SMALL SCALE PROJECT (RESIDENCES , LOW RISE BUILDINGS)
- HIGH SCALE PROJECTS (HIGH RISE BUILDINGS , MALLS)
- INFRASTRUCTURE PROJECTS (AIRPORT , BRIDGES , METRO)

RESULTS :



3. WHAT MADE YOU CONSIDER USING VIRTUAL REALITY FOR THE PROJECT

RESULTS :

-Easier understanding of project goals and issues
-Visualization

-The ability to visualise better in identifying the utility clash
-Small projects require more details
-Ability to visualize and synchronized work flow
-VR provides designers and architects the freedom and flexibility in aiding users visualize and -experience designs that aren't restricted to a physical model.

4.WHAT STEPS WERE TAKEN TO PRODUCE VR CONTENT

RESULTS :

-Outline goal, create assests, assess costs, proceed with algorithm
-BIM models pushed inside VR using enscape
-Making the model BIM complaint and making them available to VR
-3d modeling and rendering
-Understanding target audience and their expectations, Design prototyping - 3D modelling, Integration of IEs (Interactive Elements), Rendering to a VR Game Engine.

5.WHAT WERE THE GOALS SET TO ENDURE BY USING VR

RESULTS :

-Creating HVAC layout for a building
-Coordination review and constructibility analysis
-To experience a real time visualisation
-3d walkthrough videos
-To minimize the time and errors
-Provide the client an immersive experience with interactive elements in a virtual environment.

6.HOW WAS IT DIFFERENT FROM NOT USING VR ?

RESULTS :

-In terms of paper it was more difficult to work, more time taking, VR although difficult to master has made it extremely easy once it has been learnt
-VR allows better visualization and hence better understand the project

-Difficult to make any design changes during construction due to change in scope. This often resulted escalation of in cost factor
-Get a overall idea about the project
-Very time consuming and not accurate
-The client could visualize an almost finished project in virtual reality, provide critical feedback that was to be implemented in designing the final model.

7.HOW DO YOU THINK VR IS GOING TO CHANGE THE ARCHITECTURE

to visualize the project

to the conception of the project

for the communication with the client

for the communication between architects and other experts

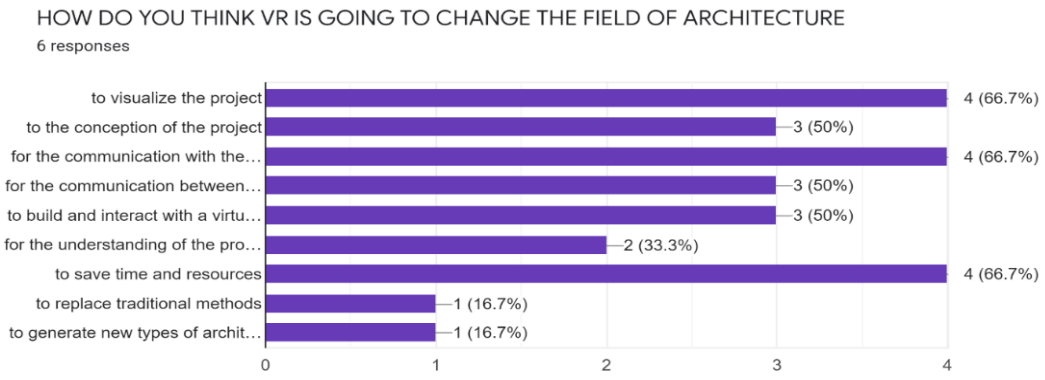
to build and interact with a virtual world

for the understanding of the project to the student

to save time and resources

to replace traditional methods

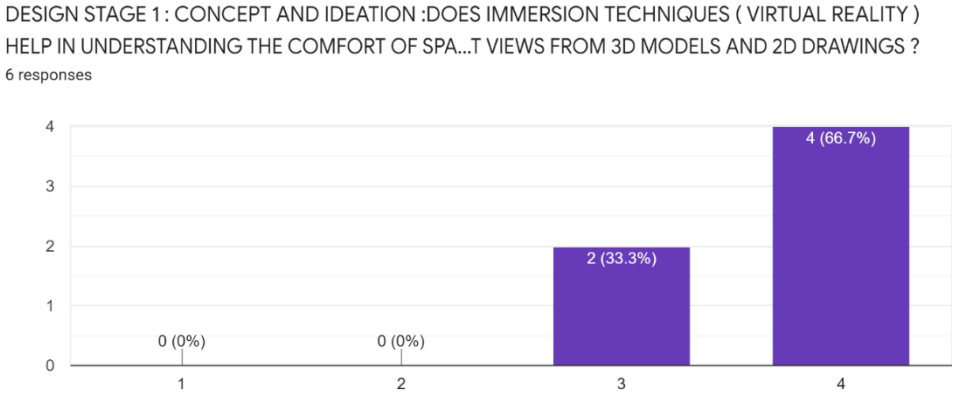
to generate new types of architecture



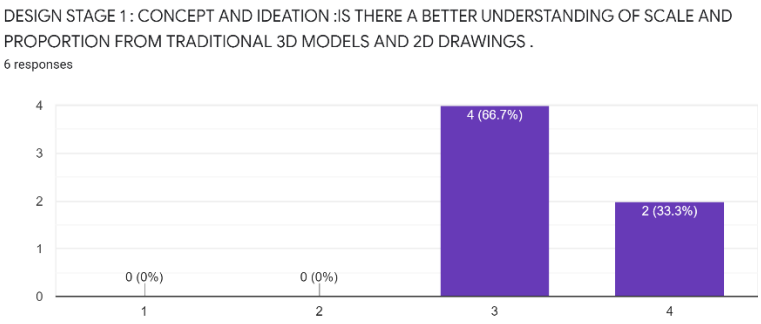
(THE INCRESING QUANTITIES OF NUMBER SIGNIFIES THE EFFECT OF POSITIVE CHANGE FROM THE TRADITIONAL TO THE EXPERIENCE IN VR)

DESIGN STAGE 1 : CONCEPT AND IDEATION

3. DOES IMMERSION TECHNIQUES (VIRTUAL REALITY) HELP IN UNDERSTANDING THE COMFORT OF SPACE BETTER THAN ABSTRACT VIEWS FROM 3D MODELS AND 2D DRAWINGS ?

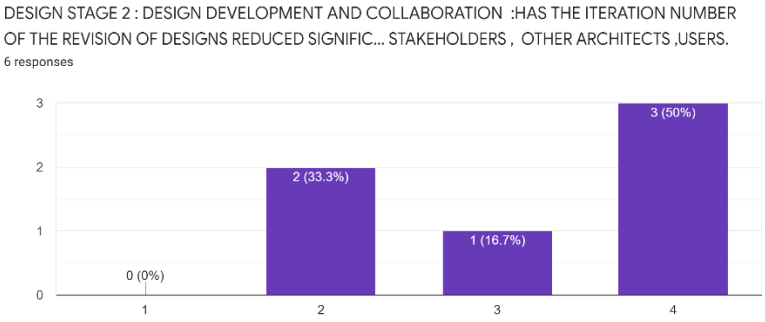


4. IS THERE A BETTER UNDERSTANDING OF SCALE AND PROPORTION FROM TRADITIONAL 3D MODELS AND 2D DRAWINGS .

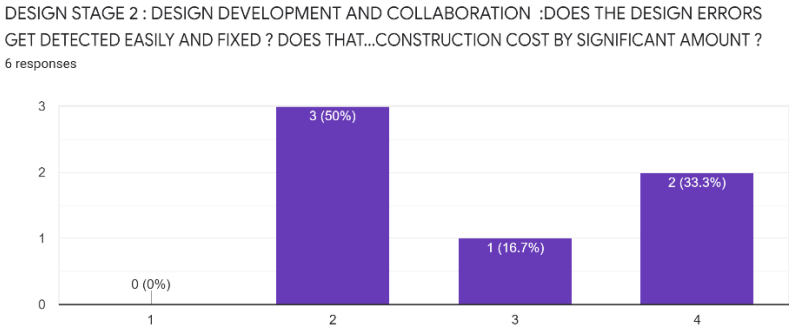


DESIGN STAGE 2 : DESIGN DEVELOPMENT AND COLLABORATION

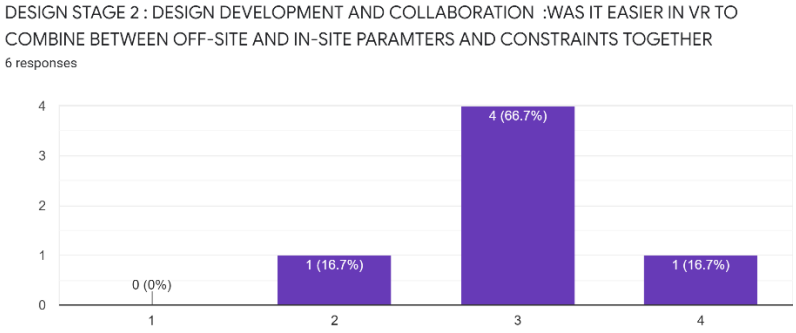
5. HAS THE ITERATION NUMBER OF THE REVISION OF DESIGNS REDUCED SIGNIFICANTLY AFTER THE INCLUSION OF VR IN THE PROCESS OF COLLOBORATION WITH THE STAKEHOLDERS , OTHER ARCHITECTS ,USERS.



6. DOES THE DESIGN ERRORS GET DETECTED EASILY AND FIXED ? DOES THAT REDUCE THE CONSTRUCTION COST BY SIGNIFICANT AMOUNT ?

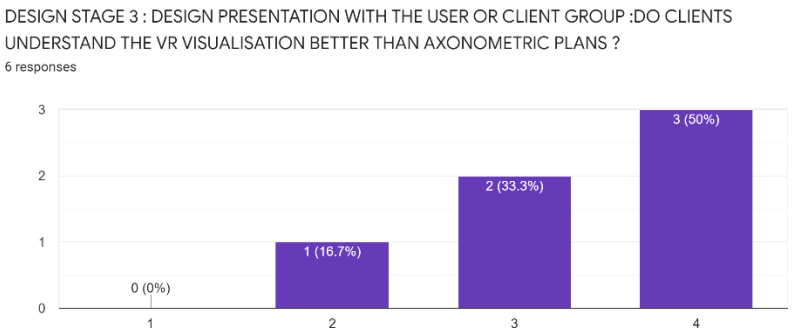


7. WAS IT EASIER FOR VR TO COMBINE BETWEEN OFF-SITE AND IN-SITE PARAMTERS AND CONSTRAINTS TOGETHER

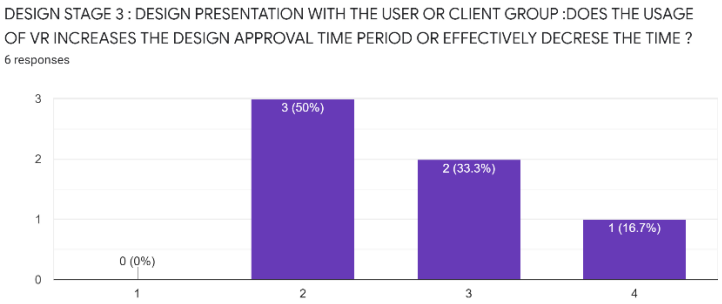


DESIGN STAGE 3 : DESIGN PRESENTATION WITH THE USER OR CLIENT GROUP

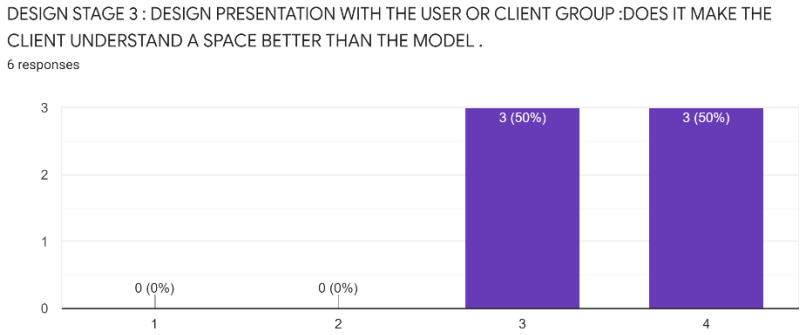
8.DO CLIENTS UNDERSTAND THE VR VISUALISATION BETTER THAN AXONOMETRIC PLANS ?



9.DOES THE USAGE OF VR INCREASES THE DESIGN APPROVAL TIME PERIOD OR EFFECTIVELY DECRESE THE TIME ?

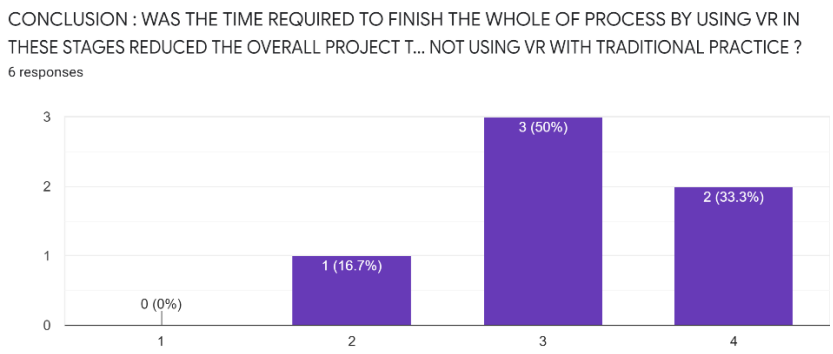


10.DOES IT MAKE THE CLIENT UNDERSTAND A SPACE BETTER THAN THE MODEL .



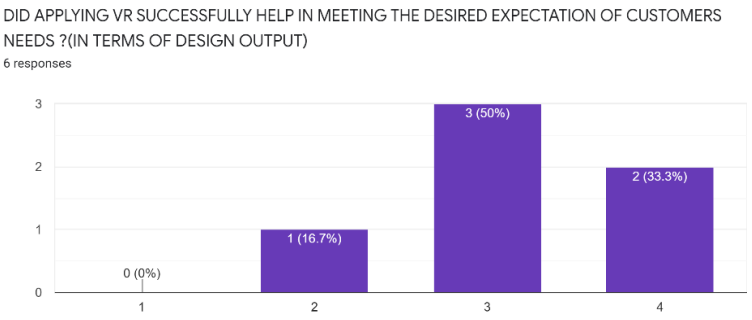
CONCLUSION

11.WAS THE TIME REQUIRED TO FINISH THE WHOLE OF PROCESS BY USING VR IN THESE STAGES REDUCED THE OVERALL PROJECT TIME AS COMPARED TO NOT USING VR WITH TRADITIONAL PRACTICE ?

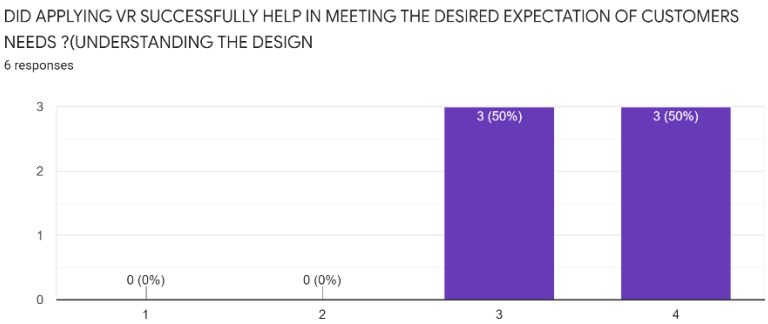


12.DID APPLYING VR SUCCESSFULLY HELP IN MEETING THE DESIRED EXPECTATION OF CUSTOMERS NEEDS ?

IN TERMS OF DESIGN OUTPUT

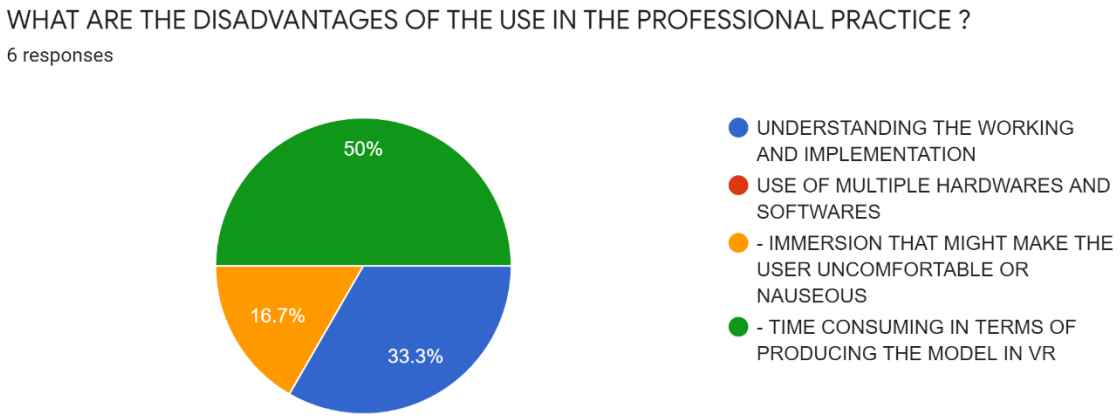


UNDERSTANDING THE DESIGN



13.WHAT ARE THE DISADVANTAGES OF THE USE IN THE PROFESSIONAL PRACTICE ?

- UNDERSTANDING THE WORKING AND IMPLEMENTATION
- USE OF MULTIPLE HARDWARES AND SOFTWARES
- IMMERSION THAT MIGHT MAKE THE USER UNCOMFORTABLE OR NAUSEOUS
- TIME CONSUMING IN TERMS OF PRODUCING THE MODEL IN VR



Results and Discussion:

The participants answered all the questions and provided rates for the design planning for both scenarios in the three different environments and their effect in 3 different stages : 2D Drawings, 3D Model, and 3D in VR. In 2D Drawings, the average rate was 4.5 out of 5 regarding the ease of using the 2D document. However, the participants provided a rating 1.9 out of 5 regarding the sufficiency of the information in 2D drawings for example the possibilities of collision between the cranes was difficult to detect in 2D drawings only. According to the participants' responses, the 3D model increased the understanding of the design plan. This was clear when comparing the overall rating for 2D and 3D; the 3D model was 3.9; However, the 2D was 3.0. The participants provided an overall rating for the 3D model when using in the VR environment by 4.4, which shows that VR enhanced the understanding of the site planning. The participants rated the ease of using VR by 2.9 out of 5, which shows that training might be needed before implementing such a technology .After analyzing the answers of the questionnaires for the participants of this experiment, the researchers discovered that a 2D drawing in planning is easy to understand and less time-consuming compared to the virtual environment. However, the participants believe that VR increased the understanding of the site planning, the ability to detect collisions, and predicting the site constraints through better evaluation of different scenarios . The research recommended that the architects that practice more using the visualization tools ,will help them, visualize the planning better and increase the level of details for the site space. Comparison between the answers of professionals in 2D, 3D, and 3D within VR.

Conclusions :

- VR is more effective than 3D model and 2D drawings regarding planning the site components and placing materials

- VR is more effective than 3D model and 2D drawings regarding detection of future collisions of construction equipment and testing different site planning scenarios

- VR is difficult to use and handle compared to 2D drawings and 3D models, which means training needs to be considered when using VR.

TRADITIONAL WORK ENVIRONMENT :

Location : walllab constructions , office

In this documentation , there is a focus on finding the work flow of a certain design project and how its carried out with 2D plans and 3D models . During the documentation every pain point was identified and and the points where the role play of virtual reality with its tools and applications can make a significant change in the quality of design decision .

Desktop virtual environment (DVE) refers to a virtual environment system that is presented on displays. The DVE has evolved animated CAD The user interacts with the environment and objects generated by the personal computer (pc) using input devices such as a mouse, keyboard, or joystick. At the same time, the computer provides feedback through a variety of media, including vision from the screen, auditory from speakers, and touch sensation from tangible interfaces.

In today's architectural profession, non-immersive virtual design environments are becoming increasingly popular. Traditional design mediums such as sketching and physical models are frequently used to represent the design idea, followed by a more thorough phase using CAD on a workstation. Finally, 3D models are created outside of the virtual environment utilizing 3D modelling software and a graphical user interface with menus and palettes. These 3D models are then seen on the same computer screen using a virtual reality viewer that displays them in a more or less photorealistic manner. The virtual environment is interacted with using the keyboard and mouse. The computer screen becomes a virtual world window. The complex interface of the CAD and 3D modelling software programs involved aids the designer by providing a few hundred functions and commands for creating, manipulating, and representing design objects. This set-up aids in the investigation and visualization of design concepts. It has a great degree of scalability, allowing designers to work on scaled representations like building layouts before zooming in to work on 1:1 details. On the computer screen, the designer can choose between 2D and 3D representations.

Some software programs also offer simulation capabilities, which can be used to anticipate environmental performance. The majority of the constraints associated with traditional tools and CAD are present in this arrangement, which is a huge disadvantage. Non-immersive surroundings, on the other hand, have recently improved in effectiveness. Wide-screen and stereoscopic displays, on the other hand, expand the virtual model's viewport and improve the 3D experience. On the software side, free-form technologies like DDDoolz and Sketch-Up make 3D computerized sketching easier during the design process. non-immersive Decision Support Environments When an immersive environment facility is only available for a limited amount of time, this approach is frequent. In this method, the designer works in a traditional non-immersive design environment and then transfers the design to an immersive virtual environment when it is nearly complete or at various points throughout the design process. The immersive sessions are beneficial for group decisions because the majority of the work is done on a traditional workstation. This strategy demands the least amount of adaptation from the designer to the new notion of immersive design and provides a very strong decision support tool. It does, however, fall short of realizing the full promise of immersive design. Rather than being used as a design environment throughout the design process, the immersive environment is employed as a presenting tool during the final evaluation stage.

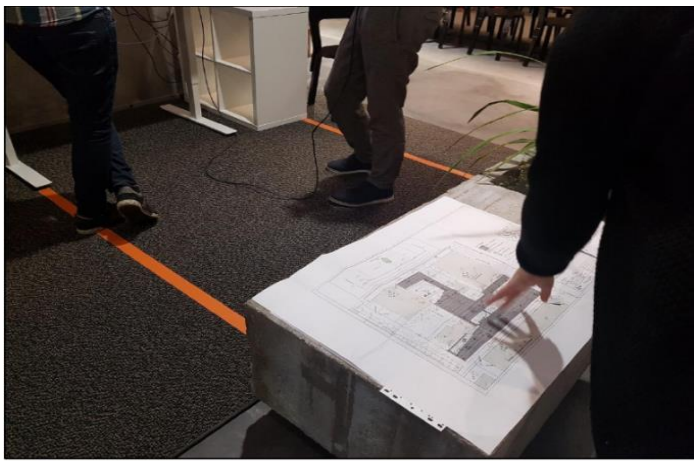


FIGURE 12 : IMAGE : SITE DRAWINGS USED IN THE FIRM (source: self taken image)

Traditional communication methods in design may not convey all of a client's problems or requirements. Correcting and altering a design without a complete understanding of the client's objective can be a slow and tedious procedure. Although designers frequently utilize CAD to aid in the visualization of potential solutions, clients with inadequate technical knowledge cannot be expected to use these sophisticated digital tools appropriately. To address this issue, this company uses a web-based virtual reality (VR) system that can be used by professionals and non-professionals to view and alter 3D visuals using a standard web browser. Clients would be able to convey their design intent by creating a virtual design utilizing standard design components provided by interior designers if they had access to an interactive

3D environment. The interior designer created a series of digital design materials and organized them into catalogues to be shown on the internet based on the information gathered through communication methods such as chat and questionnaire. The client was then shown many design possibilities in a virtual environment that was rendered on a web page.

Each alternative was created by combining virtual objects from the designer's catalogs.

This procedure would provide enough time for the client to communicate with the designer.

This company developed a specific way for integrating the VR application into the proposed communication framework. The first stage was to get the virtual design assets that would be utilized on the internet ready. They introduce X3D, an ISO standard that uses an XML-based file format to represent 3D computer graphics on the internet, and they show how to convert a CAD-based computer model into the X3D format for use online. The second step was to use these design materials in an interactive virtual world, so this firm created a web-based interface and detailed the script support needed for it to work. A proof of concept 3D was produced to test the practicality of this technology, allowing a client to build an interior scenario complete with furniture. Having different viewpoints allowed the client to explore the design options and choose the solution that best met their needs.

VR IMMERSIVE WORK ENVIRONMENT :

Location : LNT constructions , virtual reality lab

In this documentation , there is a focus on the applicability of implementing VR in a full 3d immersive design environment enhance communication, collaboration, and coordination within the project team itself and with the client. Furthermore, and because of the overseas project, there is a need to overcome challenges regarding the project location and possibility to use VR with photogrammetry instead of visiting the actual site. The main goal of the documentation was to explore and practice the integration between VR, laser scanning, and photogrammetry technologies to enhance the communication and collaboration with the client during the design process. Therefore, the client can be involved in the daily design tasks, which will reflect positively on the time, cost and quality of the project.

UNDERSTANDING WHERE WAS THE USE OF VR APPLIED :

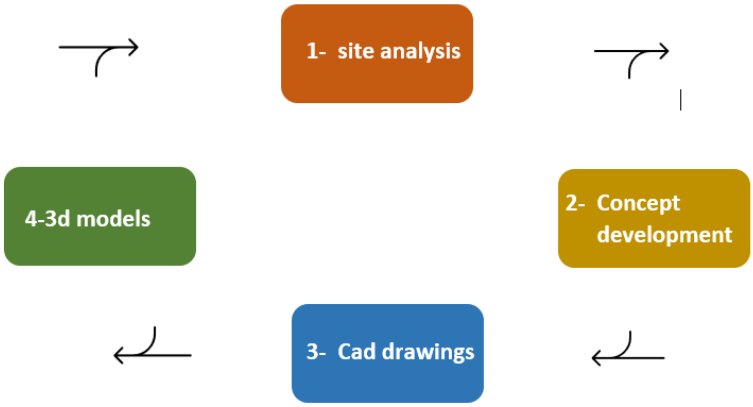
Communication: Within a VE, the client can access the VR model from his or her office and chat with the designers in real time. The client can envision the facility

features in true scale, as if they were in reality, without requiring an engineering experience.

Collaboration: The project team commits to a varied level of collaboration with the client during each phase. VR has the potential to improve collaboration in the design process. For example, numerous people can access CVE at the same time, allowing the customer to visually walkthrough with the engineers and influence the design.

Coordination: Each engineer has a different understanding and background than the other. Structural engineers, for example, can quickly grasp structural elements, materials, and loads. Finishing materials, colors, and facades, on the other hand, are easy to comprehend for architecture engineers. VR can be used to envision the project's various features, such as structural elements and architectural finishes.

Project location : Inadequate knowledge on the project's location can cause substantial delays. Hazardous situations and materials may be present at some places, posing a risk to humans. It is possible to develop a VR model using laser scanning, photogrammetry, and drones, allowing engineers to explore and investigate the site without having to travel to the location in the wild.



Stages of traditional methodology in which use of VR and its effects can be introduced in every stage

WORK THEY WERE DOING :

THEIR WORK INVOLVED MAINTENANCE AND DESIGN FOR A NEW HEAT EXCHANGE FOR THE PLANT. The facility covers an area of 1200 m2, and a high-quality laser scanner was used to build a 3D model of the project. In the high focus area, the average point density was 3 mm. To construct the 3D model, the experts scanned the entire plant in six hours utilizing 60 scan stations and 32 hours of

Processingtime. .

FIGURE 13 : IMAGE : VIRTUAL MODEL VIEWD IN THE VIRTUAL REALITY MODE(source: LNT constructions)

SETTING UP THE SYSTEM: SOFTWARE AND HARDWARE:

The HTC Vive for VR system was put up by meeting participants, who connected the headset, controllers, and base station to the laptop.

Design Space Software is a piece of software created by 3D TALO (a Finnish firm) that was used to create the VR content. The software allows users to export CAD models to a VR environment and edit them using a variety of tools. It is feasible to return to the CAD model after the user has optimized the project. The software allows you to combine several models, such as architectural, HVAC, scanned data, and so on. The same model can be used by multiple people in different places, with the option to edit in real-time. The user can utilize features like measuring and scaling, flying and walking through, drawing pipes or cubes, taking notes, and taking images within the immersive experience. Furthermore, the software can be customized for a variety of uses.

The participants entered the room after setting up the hardware and installing the software. The groups began to locate the base stations in the room by facing each other across the room's diagonal line. The trainees followed the instructions and made sure that the distance between the stations was 68 meters, not less than 1.5 meters, and not more than 3.5 meters. The trainees then calibrated the controller as well as the headgear. The controllers and headset were moved in the space between the two base stations and placed on the floor for calibration. All of the teams had trouble setting up

and calibrating the tracking area at first. The issue arose because two teams were in the same room, and the base stations were wirelessly connected, causing interference between them.

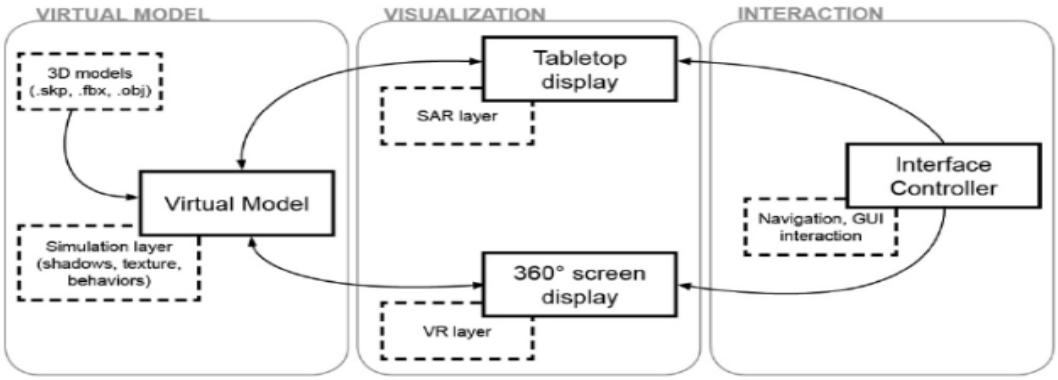
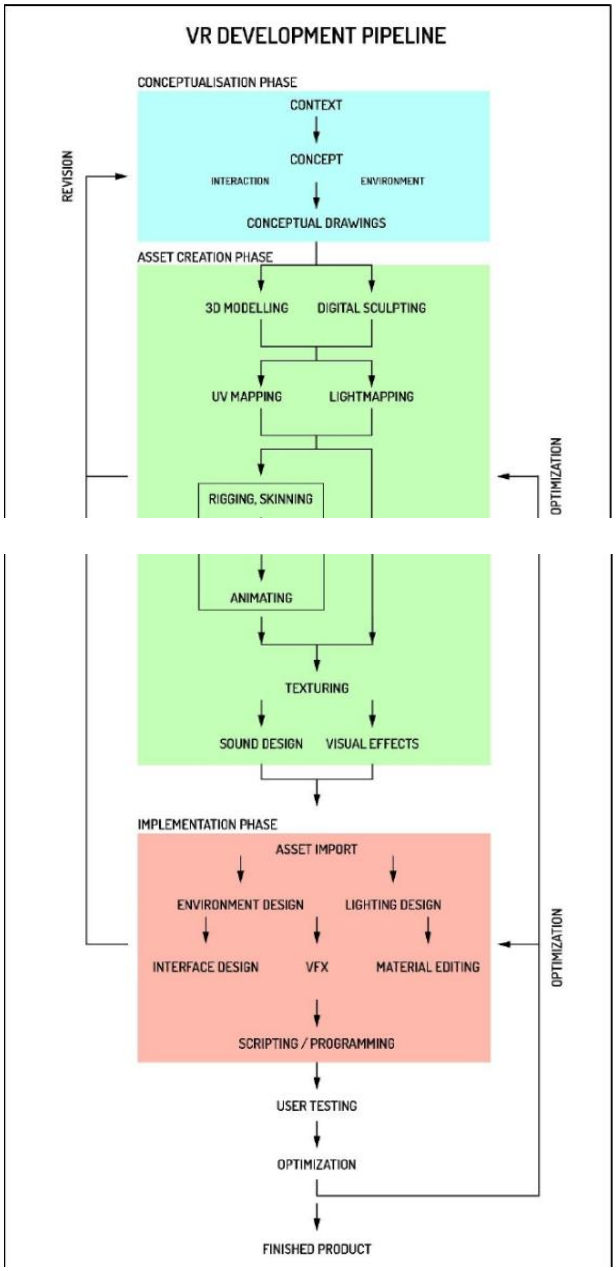


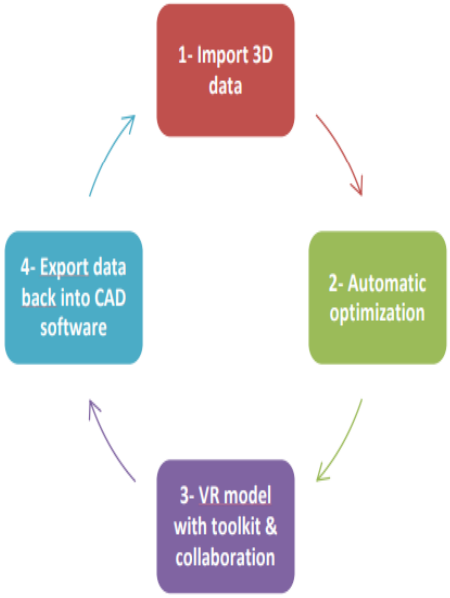
FIGURE 14 : IMAGE : VIRTUAL MODEL TO VISUALISATION TO INTERACTION (source: LNT constructions)

WORKFLOW OF DESIGN SPACE SOFTWARE :

Using an attribute reader, the software turns 3D-CAD into a virtual reality environment. The procedure and processing are simple and efficient. The method begins with the 3D-CAD data being exported to a polygon model, such as from Navisworks in FBX format. When you import a file into Design Space, the software optimizes it for you automatically. The VR model can then be edited, collaborated on, and communicated with. The software sends the changes back to the CAD model after finishing the alteration and assessing the model. Additionally, while moving in the VR model, you can draw drawings, add safety instructions, and take images.

The supervisors showed each group how to traverse the VR model using the headgear and controllers. It was crucial to learn how to maintain equilibrium while wearing the headset at first. The software in the VE creates a network that represents impediments in the room, such as walls, so that the user may avoid hitting them while immersed in the VR model. Many features in the software assist the user in making adjustments and navigating the model smoothly. demonstrates the most important features and functions.





WORKFLOW OF HOW VR CONTENT IS PRODUCED

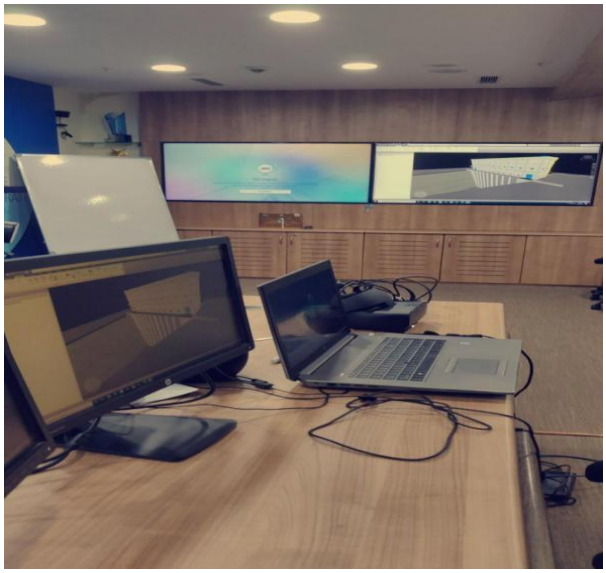


FIGURE 15 : IMAGE : VIEWING THE MODELS IN VR DURING CONCEPTUAL DEVELOPMENT STAGE (source: self taken image)

FIGURE 16 : IMAGE : DISCUSSION WITH THE CLIENTS (source: self taken image)

OBSERVATIONS :

- When the model was viewed in the 1:1 scale , the glitches in the plans and clashes between different disciplines seemed to e not be identified but when with viewing the same with VR content , they were fixed immediately .
- The attributes like the space required and provided , for every design feature were causing troubles in making the design understandable by the stakeholders and clients , which was made easier with VR being introduced at this stage .

  For example – How much head room was required Is the feature provided accessible like a valve that passed all standards of easy service access .

- Identifying the construction process called the pre construction planning phase which when viewed in VR makes the designer understand the flow of how efficiently it can be built which is a major flaw identified in 2D as these considerations are left unresolved .
- Safety checks are better considered and identified with the VR more than any 2D or 3D models as they don't let us experience it with the real 1:1 scale to actually feel the pain .

  For example – identification of sharp corners , clashes in the design

- With this better identification and understanding of flow of design has made the supply chain flow easier and not get disrupted as easily as identified in the traditional methodologies .

Conclusion from the study :

- Safety planners could simulate the construction and identify potential collisions.

- VR can provide simulation for the construction equipment and allow predicting future clashes in the site.

- Applying VR in site planning could help to predict the collisions between construction equipment

- VR with the help of laser scanning and photogrammetry could be useful for investigating hazardous sits

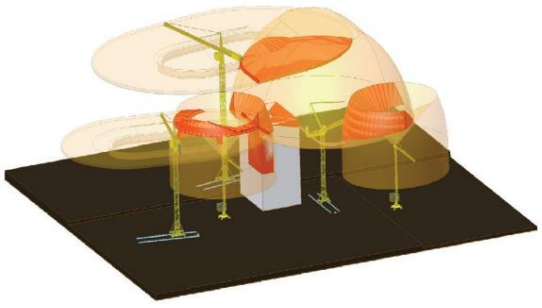


FIGURE 17 : IMAGE : Source: (Ebner;Kammergruber;Horenburg;& Günthner, 2012) 3D MODEL SHOWS POTENTIAL COLLISIONS BETWEEN CRANES AT THE CONSTRUCTION SITE

CHAPTER 4 – CONCLUSION

SUMMARY OF RESEARCH:

Comparison of 2D plans and 3D immersion:

The design process is tracked down and the comparison between the different effect of each stage in making a quality design decision is marked.

SNO	FEATURE	2D PLANS	3D	3D IMMERSION
1	SITE ANALYSIS AND SITE PLAN			
2	CONCEPTUAL DEVELOPMENT			
3	CONCEPT DECISION MAKING			
4	CONSTRUCTABILITY TESTING			
5	DRAWINGS GENERATION			
6	TESTABILITY BETWEEN DISCIPLINES			
7	REVIEW MEETING			
8	SAFETY CHECK			
9	CLASHES AND GLITHCHES INDENTIFICATION			
	(BETWEEN DIFFERENT DISCIPLINES)			
10	CLIENT MEETING			
11	USER TESTING TO THE DESIGN			

The outcomes of the research give a thorough comprehension of the issues raised in the dissertation. The major goal of this article is to determine the effectiveness of virtual reality's contribution to the field of architecture. The goal was to bring out the attributes through various kinds of research on ideas and practices in order to have a thorough grasp of the problem.

- To begin, the complexity of a decision-making process in the field of architecture is addressed, along with the requirement for a better platform to be introduced in order to create successful decisions. It is discussed by how VR can effectively bring about a change in this gap that has been identified as a stumbling block to the industry's growth. As a result of the use of virtual reality in various stages of the design process, more responsible judgments can be made.

- Furthermore, through doing actual study on virtual reality laboratories in organizations that use them for the design process for a variety of projects, the role of VR has been clearly proven. The study is based on a good response from consumers who have witnessed a departure from traditional design techniques. The usage of

virtual reality to interact with various features can be used to build a well-designed setting with more value than ever before.

- Virtual reality has not only opened up new possibilities in architecture, but it has also enhanced current ones. Due to current Software and Hardware Technology restrictions, VR applied in architecture may not be as compelling as the real thing.

- However, it allows us to execute tasks that were previously impossible or treated in such a way that they can be done more effectively, with much more to come from future technological advancements. Your difficulties are unlikely to go away very soon. According to our findings, even with its current limitations, virtual reality has the potential to change the way we think about and build the physical environment, pushing it beyond space and time limits.

RESEARCH OBSERVATIONS AND ITS SIGNIFICANCE:

In the previous seven decades, virtual reality (VR) has advanced swiftly and demonstrated its efficacy in a variety of industries; yet, its application and implementation in the architecture industry are still limited. The unique nature of construction projects and the expensive expense of VR technology in the past are the main sources of this limitation.

- Multi-disciplined engineers, stakeholders with varying interests and backgrounds, high-profile clients, and wary end-users are all involved in construction projects, particularly infrastructures. As a result, in such projects, a lack of communication, collaboration, and coordination leads to errors and problems during the design and construction phases.

- Furthermore, clients and stakeholders without an engineering experience may find it challenging to comprehend the design, particularly early in the design process when information is scarce. During construction, the project may encounter allegations from end-users or stakeholders who misunderstand the project.

- On the other hand, VR technology has advanced significantly, not only in terms of hardware and software, but also in terms of cost, which has dropped considerably in comparison to 15 years ago. As a result, several developers are striving to apply virtual reality to the architectural sector. The design team can employ VR within CVE to improve design review and approval by enhancing communication and collaboration and minimizing revision and approval time during the design process.

-In addition, when a designer is immersed in a real-scale 3D model, their comprehension of the space and design aspects can improve. Within CVE, facility operation and maintenance teams can simulate operations, maintenance, and even evacuation plans, as well as provide feedback and suggestions on the design. Within a

VE, clients and decision-makers can have access to accurate and up-to-date data, allowing them to make faster, more dependable, and precise decisions. Within a VE, stakeholders and end-users may examine how projects will affect the environment in the future and even walk about and check out the facility virtually. The method and ability to create the facility should always be considered in a good design. Before the construction phase begins, VR can be used to replicate dangerous locations on future sites and give workers with pre-construction safety training.

-Architects can also detect and rectify possible collisions that could result in accidents. Designers can model the succession of construction parts using construction stage management. When creating site planning and before to the start of the execution phase, architects can model the dynamic process on the construction site. This could help you get the most out of your job and your resources.

-We can give a framework and methodology to highlight the benefits and limitations of using VR in the architecture design process through a literature review, examined case studies, and participation in a documentation for incorporating VR in the design process. It may be determined that implementation will provide the department with numerous benefits. The VR model can be used to communicate with clients within the VE, allowing them to see the most up-to-date design and choose from many options. Meetings can be recorded in the VE with the ability to take notes and comments, which can then be used to create meeting minutes. The VR paradigm can be used in mega-infrastructure projects to engage stakeholders in the design process and boost end-user satisfaction.

- Within a CVE, designers and modelers may better comprehend and alter design components, as well as interact with one another. Finally, the model can be used for operational, maintenance, and as-built documentation planning.

LIMITATIONS:

The real implementation of VR still faces challenges regarding technology limitations or cultural aspects. VR still needs traditional modelling tools and cannot work independently from 3D modelling software. Creating a CAVE requires a permanent place and high cost, which limited the application only for high budget projects. The implementation may not cost efficient with simple and small size projects where traditional 3D models can be sufficient. In addition, some people feel sickness and dizziness when using VR headsets for a long time. Some clients feel comfortable using the headsets within a big group. Due to the lack of research time, there was a shortage in investigating the future approach proposal.

covering the needs of a wide range of participatory group:

-Use a variety of tools: When creating a participatory urban design process, it's critical to use a variety of tools and methodologies. Various case-specific informal tools and

approaches should be utilized to incorporate everyone who is expected to participate. While using technology tools, traditional approaches should not be omitted from the process. HMD users who do not want or are unable to utilize them should not be excluded from the study. Smartphones and personal computers are today's household items, yet 6 DoF HMDs are not. A flat screen version of the experience should be given for persons who do not want or are unable to utilize an HMD.

-Include comfort modes and take accessibility into account. Participants who struggle with mobility or other aspects of the experience should be given the option of using a simpler alternate mode of navigation and participation. People with disabilities should be considered.

-According to the goal of the participative process, accessibility mechanisms may be designed. Colour blindness, for example, might be considered during the conceptualization process and colours chosen accordingly.

-Use VR as soon as possible: VR is a powerful tool for presenting finished, polished environments with a high level of realism. However, at that point in the design process, major decisions are difficult to change. If a VR-based tool is to be built and used, it should not be left until the very end of the process, when key decisions are nearly made. Instead of displaying an impressive visualization device, designers should view VR as a tool to bring the body, and thus the reality of the participant, to a created environment, with the goal of including participants in the decision-making process.

-Playtest: Because everyone's body is different and everyone's experience with tools is different, the only way to create natural and intuitive body-centered interaction design for a large audience is to conduct numerous test sessions. Testing and iterating is a time-consuming procedure, but it guarantees that the design is simple to comprehend, even if it requires the participant to exert effort in order to use it.

-Adjust and use frameworks, templates, and built-in tools. Creating an interactive tool from the ground up is a time-consuming task. Using existing assets, frameworks, templates, and technologies reduces development costs dramatically. However, such ready-made information should be modified as needed; otherwise, the content will inevitably become generic. This is especially true when it comes to the virtual reality function of teleportation. Keep it brief and give people the option to extend their experience. For many individuals, virtual reality is an uncommon medium. For some people, having a display close to their eyes or using locomotion techniques can be exhausting. Participants should not be forced to play for an extended period of time and should be allowed to do so if they so desire.

-Use all three illusions to heighten presence. With vast, realistic surroundings and multi sensory gear, Place Illusion (the illusion of being in a place that does not exist) is easily

accomplished. The plausibility illusion, or the illusion that what is going on is real, is more difficult to achieve. Innovative approaches should be devised to assist in the creation of a new reality in which everything follows its norms. An object's physics should be compatible with the physics of another object. In the generated (virtual) reality, everything should be in order. Because the virtual body of the participant is based in that reality, its interactions should likewise follow the laws of that scenario, if not create them. Such interactions are expressed through body-centred interaction strategies. Ownership of the Human Body The illusion of having a virtual body can be created by tracking the body in sections or in its entirety. In 6DoF applications, the first stage, implementing hand presence, is the industry standard. Body trackers can be used to construct complete body avatars in location-based applications, creating a full body illusion. IK can be utilized for complete or half-body illusions in home setups. Bringing the (virtual) body into the generated (virtual) world takes immersion to a whole new level. On a subconscious level, believing that the virtual body is their own body permits emotions like empathy to play a larger role in the experience.

To summarize, in a participatory project, using a well-designed VR experience with multi-sensory modalities and a human-centred interaction design approach will boost interest in the suggested design and motivate participants to think about and provide suggestions. Intuitive, natural body-centred interaction is required if the participation process has a high participation level that permits the participant to influence the design. Not only does having a full or partial virtual body boost one's sense of presence, but it also opens up exciting design possibilities for community empathy.

FURTHER RESEARCH AND CONCLUSION:

The subjects demonstrated the fallibility inherent in different virtual representations, be it CAD or VR, and through examining their design processes, we can better understand how CAD and VR

- Affect perceptions of scale

-Object relationships

-Materiality

-Open spaces.

Better intuitive understandings of scale and object spatial relationships are naturally supported by VR, but it does so in an immersive way. Scale, density, and immersion are all illusions created by CAD. In VR, both no texture and realistic produced textures can be used, with realistic drawn textures having a slight advantage.

Finally, when self-evaluating their immersive 3d spatial imagination from a plan, architects and novices perform nearly identically, with architects marginally outperforming novices.

- These findings show that virtual reality has potential as a unique and worthwhile new medium for architecture design. The project also provided an opportunity for some brainstorming about future VR applications.
- Different experts chimed in on the various applications of virtual reality. One especially intriguing suggestion was to design from the standpoint of individuals who aren't currently considered, such as children's perspectives or wheelchair users with unusual lines of sight.
- Some people saw virtual reality as a useful tool, but not as a substitute for traditional CAD modelling, and there were many varied perspectives on its location and role in the design process.
- On a larger scale, the development of the VR review tool into a VR editor tool would be the next stage for this project and research. We could do a more extensive comparison between CAD and VR designs if we developed the VR proof of concept into a full VR editing environment.
- This potential piqued my curiosity at the start of this project, but the problems in constructing adaptable VR metaphors to alter space proved to be quite a struggle. How items could be moved and operated far away from the body was one example of such a challenge. One of several object manipulation concerns was whether the user would have to move with the object in order to put it.
- For an immersive virtual reality environment, the metaphors that enable modelling would have to be rebuilt. Design, the act of producing, and architectural modelling in virtual space would all be transformed as a result.

BIBLOGRAPHY :

INTERNET SOURCES :

https://www.theseus.fi/bitstream/handle/10024/264766/Mabrouk_Omar.pdf?sequence=2&isAllowed=y

https://ttu-ir.tdl.org/bitstream/handle/2346/12601/hao_wu_thesis.pdf

https://dspace.mit.edu/bitstream/handle/1721.1/111278/1003490094-MIT.pdf?sequence=1

https://blog.irisVR.com/blog/case-study-agora-architecture

https://www.ourstudioltd.com/2017/09/virtual-reality-architecture-interior-design/

https://www.researchgate.net/publication/344556882_A_DESIGN_GUIDELINE_STUDY_FOR_AN_IMMERSIVE_PARTICIPATORY_URBAN_DESIGN_TOOL

https://publications.lib.chalmers.se/records/fulltext/254816/254816.pdf