

Analysis of Building Information Modeling (BIM) using Virtual Reality (VR) and Augmented Reality (AR) Techniques in the Construction Industry

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Abstract

With advances in Building Information Modeling (BIM), Virtual Reality (VR) and Augmented Reality (AR) techniques have many potential applications in the Architecture, Engineering, and Construction (AEC) industry. However, the AEC industry, relative to modern information and communication technology (ICT), has been slow in adopting AR-VR techniques, partly due to lack of feasibility studies examining the actual cost of implementation versus an increase in profit. The main objectives of this paper are to understand the industry trends in adopting AR-VR techniques and identifying gaps within the industry. The identified gaps can lead to opportunities for developing new tools and finding new use cases. To achieve these goals, current construction projects are characterized by short-term partnerships between multidisciplinary teams with varying levels of process maturity and information handling capability. They involve the planning, Architectural Design, and erection of structures of all types. Compared with other industries, the construction sector has relatively poor profit margins and low-efficiency levels. The product development process in construction is still structured as a sequential chain of activities in which each activity is separated in time and space and where Architectural Design information is communicated using traditional documents, such as 2D drawings and written specifications. This process is slow and error-prone and reflects the functional orientation of the construction project. However, lessons learned from the manufacturing industry have shown that new AEC processes using ICT tools such as BIM and AR-VR techniques can increase efficiency and reduce lead times. So far, AR-VR has been used sporadically in the construction industry, often from the perspective of visualizing the product AEC for the client. The objective of current research has been to investigate how AR-VR can be used during the planning, Architectural Design, and realization phase of a construction project with the emphasis on complex building products using 3D. The main objective during current research has been that the use of digital prototypes visualized AEC Design to improve the decision-making and thereby the final product.

AR-VR techniques both play vital roles in the construction industry. AR-VR techniques, however, have a higher benefit when compared to Real. This analysis with their similarities and differences based on past, present, and future using AR-VR techniques are illustrated. The drawbacks are mentioned, with the way to correct them detailed.

Keywords: virtual reality; augmented reality; building information modeling; industry trend; virtual environment

1. Introduction

New constructions begin in the imagination and migrate to the physical world. But before ground breaks, an array of stakeholders invests upfront in the proposed outcome. As expectation, reliable, predictive, physical information and simulation provide required utility through time and cost savings. Both AR-VR techniques include pre-visualization offered by virtual reality (VR) and the extra layers of vision provided by augmented reality (AR) increase investor confidence and boost efficiencies for architects. Currently, in the 20th century and beyond, the AEC has seen monumental changes in a wide variety of aspects. In the proposed analysis, there has a huge transformation in the construction industry. Through building bigger and better things, the industry has revolutionized means and methods [3]. Besides, to overcome the shortage of competent workforce, the construction industry has taken advantage of technology to better recruit and retain new workers in a construction career [8]. One of the technological tools employed by the construction industry is called AR-VR techniques, in which a 3D, computer-generated environment can be explored and interacted by a person. AR-VR shares the same concept, but rather than interacting in a non-existing environment, AR-VR uses the existing environment while implementing virtual elements to appear as if both are together at the same time [6]. The purpose of this analysis is to explore the changes in the construction industry that are resulting from AR-VR techniques. In technical terms, AR-VR is described as a computer-generated 3D environment that can be explored as well as interacted with by an individual. The Architects and 3D models go hand-in-hand. The advent of VR means they no longer have to Alice in Wonderland their way through dollhouse models. Visualizing two-inch versions of themselves peering into tiny windows and walking through tiny doorways and had to be a better solution.

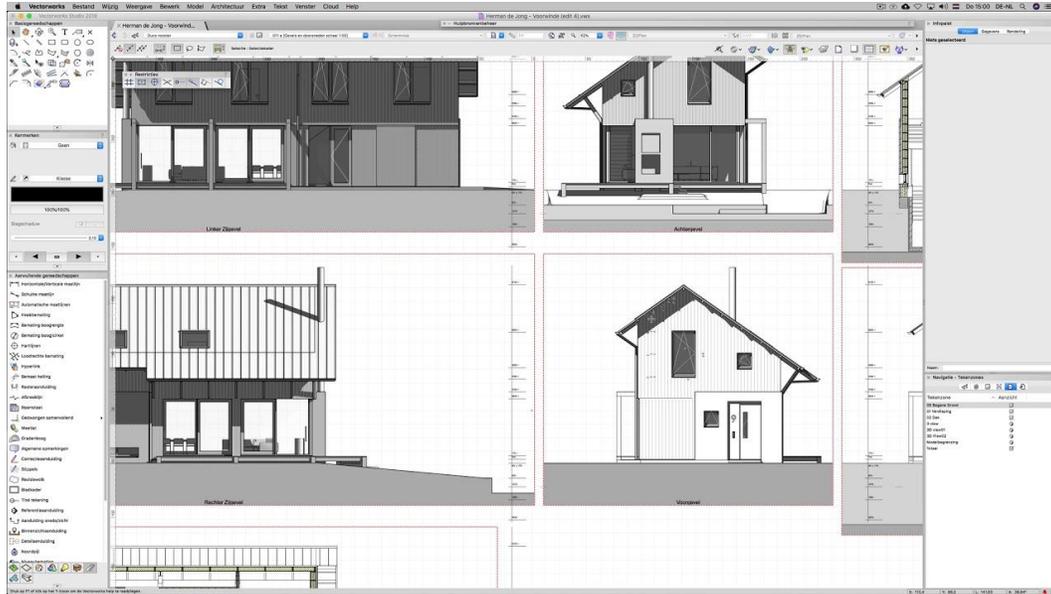


Fig.1 AEC Design using BIM App

The Architecture, Engineering, and Construction (AEC) industry with expenditure increase as demand raise [1]. However, over 98% of construction projects incur cost overruns and delays [2]. Many projects experience rework, costing 5% to 20% of the total contract value [3]. The main causes of rework include lack of communication among different construction parties, lack of adequate visualization capability to recognize design conflicts, and lack support for advanced communication technologies [4]. The proposal overcomes deficiencies that can decrease the number of unforeseen issues and, therefore, rework in construction projects [5]. Since the past decade, Building Information Modeling (BIM) has found a wide range of applications in the AEC industry is shown in Fig.1. Global reports indicate that currently BIM is utilized heavily by AEC companies and within one year more than 90% of the entire industry will completely utilize BIM in their projects [6]. In this proposed methodology, BIM is defined as the process of generating and involving a digital representation of a building or construction and its characteristics. BIM is not just the production of 3D models [7], therefore, it can be used for different functions such as improving communication, decision-making enhancement, and visualization. Although, it can accelerate information integration from design to construction [8]. BIM technology has improved and revolutionized the way designers, engineers, and managers think about the buildings and enable them to predict and solve problems that might occur during the life-cycle of a building. BIM technology has enabled designers and engineers to detect clashes and simulate different construction scenarios for more efficient decision making. It revolutionized the AEC industry in many different aspects, such as technical aspects, knowledge management, standardization, and diversity management [9]. For instance, BIM does not provide robust visualization for cluttered construction sites and the existing software packages provide limited user experience (i.e., lack of interactive visualization using a keyboard and mouse) [10].

Moreover, investigations have shown that BIM has some limitations in real-time on-site communication [11].

Additionally, the stakeholders who are not familiar with BIM solutions are not able to utilize its capabilities, such as improved communication through visualization and immersion. To address some of the inherent deficiencies of BIM and open a new area for enhancement in AEC, researchers proposed the use of new technologies such as Augmented Reality (AR) and Virtual Reality (VR). In this proposed methodology, AR is referred to as a physical environment, whose elements are augmented with and supported by virtual input, and VR is referred to as a simulated virtual environment, representing a physical environment. Accordingly, Immersive Virtual Environments (IVEs) are environments where user interaction is supported within a virtual environment. AR-VR techniques can potentially address these deficiencies and enhance BIM in several aspects, such as real-time on-site communication [12]. AR-VR can also improve communication among stakeholders and provide better visualization for engineers, designers, and other stakeholders, enabling one-to-one fully immersive experience [13]. Furthermore, IVEs has the necessary potentials to achieve knowledge synthesis to improve the design process [14]. Many industries successfully implemented AR/VR. For example, AR-VR has applications in manufacturing, retail, mining, education, and healthcare, especially for simulating surgeries. Recent studies indicate the benefits of AR/VR in the AEC industry by demonstrating potential applications, such as safety training, visualization, and communication [15], and energy management. Although research suggests AR-VR techniques can be very effective, the AEC industry has been very slow in adopting these technologies, which could be partly due to lack of feasibility, examining the actual cost of implementation versus an increase in profit.

2. Objective of AR-VR Techniques

The main objectives of this proposal a) determine the trends in adoption of AR-VR techniques in the AEC industry, b) predict the future and vision of the industry experts on the adoption of these technologies, and c) detect the limitations of the utilization of these technologies. The following section summarizes AR/VR studies in other domains and then in the AEC domain. The Method section lays out the main hypothesis and presents how the questionnaire was formulated and distributed to industry experts to achieve the three objectives as listed. Entire AEC industry experts have provided their feedbacks and visions on the growth and utilization of AR-VR techniques within the construction industry. The questionnaire was designed to analyze the growth of these technologies by collecting responses at two different time intervals (2018 and 2019). With the analyzed survey results, the Survey Findings and Results section presents the industry trends from 2019 to 2020 and provides insights on the industry's visions on the future of AR/VR technologies and the main opportunities for the AEC industry. Finally, the Conclusion section summarizes the paper and discusses the limitations and new potential applications for the construction industry.

3. Implementation of AR-VR Techniques

The implementation of AR-VR techniques is still relatively new within the AEC industry; we collected some information regarding the trends and utilization of AR/VR tools and tested the same in three hypotheses of research methods. First, we designed a detailed online questionnaire. The detailed questionnaire was reviewed through BIM specialists as well as researchers within the field of construction engineering and management to ensure questions are clear and not misleading. Secondly, based on the questionnaire in which we analyzed the growth of these technologies by collecting responses at two different periods. Finally, through the survey results, we identified some of the industry trends from 2019 to 2020 and provide some information about the industry's visions on the future of AR/VR technologies. The questionnaire is formulated to gather information about the AEC industry's adoption of AR/VR technologies from 2018 to 2019. Moreover, the questionnaire investigated the opportunities for AR/VR technologies to improve stakeholders' communication and identify experts' predicted return on investment. The survey enabled the authors to keep a record of the computer address from which the survey was completed using internet protocol (IP) and assign an identification number (ID) to the user's IP. The survey excluded duplicated data by checking respondents' profiles, IPs, IDs, and entries from the database for analyzing survey results. The excluded responses were mainly from the respondents who did not complete the survey so that the authors could not accredit their credibility for the goals of this research.

- ❖ Help prevent delays and budget issues with early detection of incompatible elements.
- ❖ Project teams don't have to address concerns about the applicability of a constructed mockup.
- ❖ With direct AR overlays, contractors access measurement data, field conditions, and all past design iterations. In this way, we can make precise changes rapidly and with confidence.
- ❖ Know how much material has already been used, and how much will still be needed. Eliminate wastage and undersupply, and provide materials ahead of time, with no work slowdown.

Thus, augmented reality apps like Pair and Virtual Apt allow architects and project owners to drag and drop 3D models of furnishings into interior spaces. Office furniture, lush plants, art, and wall coverings can all boost the appeal of empty commercial space when viewed through an AR app.

4. Development of AEC using AR-VR Techniques

- To learn Softwares i.e. Auto CAD, Unity, Photoshop, and Revit Architecture.
- Architectural Designs of Virtual sample flat in AR-VR APP

- Architectural Designs of an existing building in AR-VR APP
- Developing modern affordable cardboard AR-VR models

4.1 AR-VR Realities in AEC

➤ Exciting users through visual interactions

When AEC projects limit themselves in 2D, they rarely offer more information to the customers; so, missing that X-factor. The 3D architectural sketch makes this information more meaningful. Fig.2 Shows 3D AR-VR Reality Authoring Environment. By presenting all such construction projects in Augmented/Virtual reality, clients can get a total visualization of the property view from every possible angle. An Augmented/Virtual reality app can produce a 3D representation of the property view from a 2D image. In Augmented/Virtual reality, the users will be able to do Augmented/Virtually anything with a real view model. For example, through Augmented/Virtual reality, a house can be stripped off from the base to view the layouts of different floors. Similarly, many more things can be possible to view.

➤ Transparency on the product/service offered

A simple example can clear this service. Place yourself in the garments of your customer. Now imagine a scenario. You click on an app on your smartphone and select a property of your choice that you want to check out. In Augmented/Virtual reality, you'll be able to hold up your phone and create a window into your selected property. You'll Augment/Virtually be able to walk around the property, check out anything as you wish. You'll also be able to walk down the street and discover new properties on the app. Just point your phone at any house (which is up for sale) of your choice and see several real-time stats on your phone itself, such as the price, status, contact information, etc. All such things are possible with Augmented/Virtual reality. So, you see that AR-VR does provide transparency on the products/services offered.

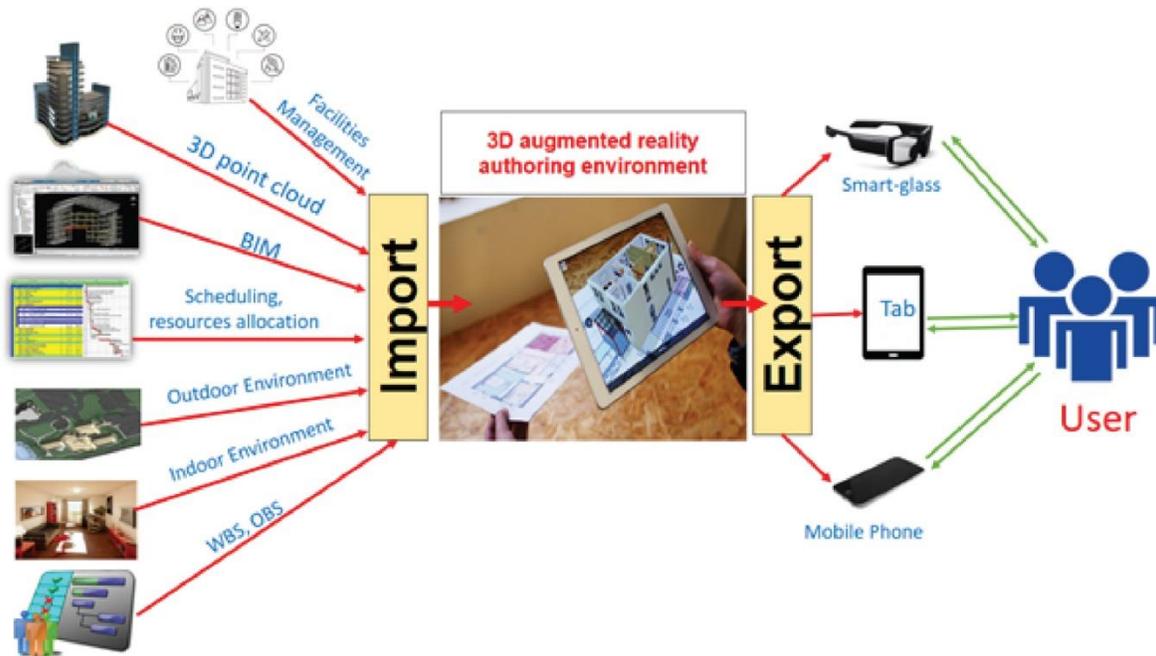


Fig.2 3D AR-VR Reality Authoring Environment

➤ Publicity in AEC

The use of Augmented/Virtual reality in AEC businesses is greatly capable of capturing the attention of the customers. It has been found that customers who have generated good interest in a specific property viewed through an AR-VR device are more likely to involve in a conversation associated with the company; so spreading the word around. Bigger engagements from these campaigns lead to higher excitement, which in turn, results in increased publicity. Customers who have found an affinity to a particular property have a natural tendency of consulting with their family, relatives, or friends. That, in turn, results in more publicity. And since Augmented/Virtual reality is an Avant-grade form of technology, its inclusion can cause quite a stir among the public.

➤ Mobility

Using Augmented/Virtual reality techniques, you will be able to provide your customers with AR-VR tours anywhere, anytime and from any place of your choice. People who are taking such AR-VR tours can also reach certain vantage points that might be physically impossible for human beings to reach and visualize their choice of property to their heart's content. The experience is undoubtedly very gratifying.

➤ Attention to customer reach

Mobile applications supporting AR-VR features are readily available on smart mobile devices. Given this ease of access, it can be said that there isn't any easier way to reach potential customers with all required information on apartment and house availabilities other than this one here. All such project information can be seen anywhere as per convenience in the form of an

interactive brochure. All that's needed is a smart mobile device, an app, and the brochure of the company. You can easily and conveniently build up your AR-VR portfolio and refer to all those projects offline as per your requirements. That makes your tasks a whole lot easier in a meeting or in an event where you are required to present some of your sample works or ideas.

➤ **Economic-saving**

Augmented/Virtual reality, present days is considered to be one of the most economic ways of growing a business and surpass geographical barriers. Overcoming geographical barriers means more potential customers which, in turn, leads to better growth in business. Thus, this point alone nods the favor in the direction of VR especially when the business in concern is one that's based on AEC.

➤ **Improved Brand Royalty**

Augmented/Virtual reality is not all about driving sales. It's one of the most effective ways of improving your brand loyalty. Your customers might be intrigued enough to come back to you again and again. If you are looking to buy a property, and Augmented/Virtual reality app can be immensely beneficial for you to help you make the right decision. With an Augmented/Virtual reality app, you will be able to take Augmented/Virtual tours of any property anywhere on your mobile phone. Through an Augmented/Virtual reality app, you will be able to scan a banner, a flyer, or any sort of printed material that has an integration of Augmented/Virtual reality in it. You will simply be able to see the property come to life. Thus, searching becomes much easier. VR will also make it much easier for you to find the location of the property. It will also help you know the exact distance from your location to that of the property. You will be able to know the details of the property on the app itself like the total area of the property, the price, number of rooms, etc. All such information will be beneficial for you to make your decision accordingly.

5. AR-VR Reality App Set-Up

AR-VR Reality Tours from society gate to sample flats from the convenience of your office or the Smartphone.

- ❖ 360° image tour: all images with a 360° view
- ❖ Cardboard view of the proposed project
- ❖ An immersive experience with a cost-effective

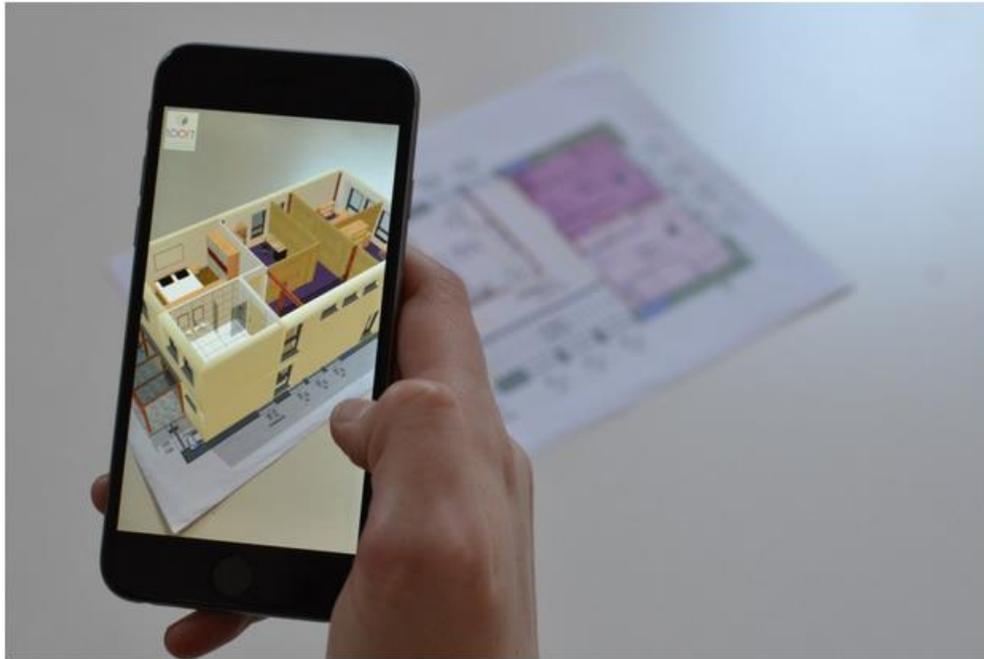


Fig.3 AR-VR App Visualization

Fig.3 shows the AR-VR App Visualization. It includes all the access to the View VR, 360°, Location, amenities provided, and specs of the structure. Further, fig. 4 shows the detailed tabs of some of the specification galleries of AR-VR Mobile App for Architecture includes some of the 360° views of the sample flat followed by the Cardboard views in fig. 5 shows Comparison of AR-VR-MR Reality.



Fig.4 AR-VR Mobile App for Architecture

From the consideration of the entire above proposal, we conclude that our AR-VR app is ideal for a replacement for the sample flat. Present AEC who want to venture into AR-VR need to buy their headsets and equipment for cardboard view it's powerful enough to capture a 3D view or scan of the design layout in compatible with the headset. Hood has used with compatible 3D view or scans from Matter port, a 3D imaging provider real-time experience as viewers move from room to room by focusing on a dot in the software projects onto the image of the room. We provide AR-VR app with MR, which includes the 360° view and cardboard view respectively.

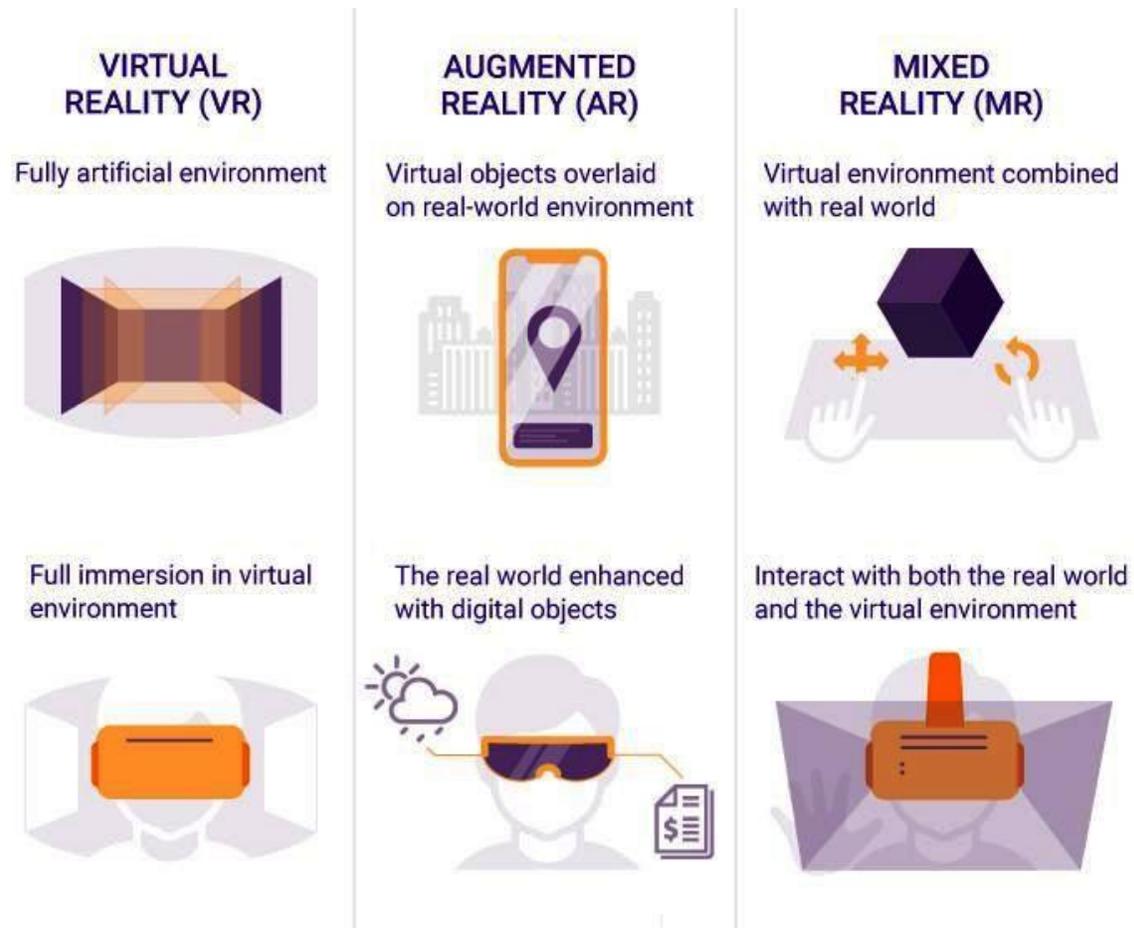


Fig.5 Comparison of AR-VR-MR Reality

6. CONCLUSION

The purpose of this proposal was to explore the changes in the AEC industry and to achieve our aim and objectives like time and cost-saving with the help of AR-VR App. Sample flats in AR-VR App as compared to the Sample flat in existing gives more beneficiary results. Meanwhile, research has shown that Virtual technology is a supplement of construction technology, giving users a real-time view of what is occurring before them. It is clear from the research reviewed that these great improvements in Virtual technology are affecting the industry in multiple ways.

For example, when trying to get a picture of how a final project will look during different stages in the construction process. Along with this, it is also clear that Virtual technology can greatly improve the effectiveness of safety training because it allows people to get a real-time view of different situations on the job site. Even though Virtual technology appears to be an important tool in the construction industry, it has some drawbacks but it is almost certain that technology will play a critical role in construction for years to come.

7. Reference

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