

Case Study on Virtual Reality in Construction

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Virtual reality has evolved into a practical technology that has recently been introduced across many different industries. In the construction industry alone, the innovative tool has started to show its worth by limiting rework, time savings, and identifying design flaws. This case study outlines the goals, benefits, and challenges for virtual reality in construction as it relates to BNBuilder's Spectrum/Vertex project. Due to the infancy of the technology, suggestions were collected from the interviewees and discussed in the subsequent paragraphs. The information for this case study was collected from: phone call interviews from BNBuilders' field and office employees, the vice president of Vertex Pharmaceuticals (who will occupy the building), and the architect on the project. The findings of this case study were that BNBuilders was able to identify design flaws, save money, and save time.

Key Words: Virtual Reality, Design Flaws, Time Savings, Limiting Rework

Introduction

The integrity of any construction project requires all parties involved to “buy in” to a mentality focused on managing time, cost, and quality. An uncorrected slip-up in any of these three categories can result in an unsuccessful project that loses money for everyone. One of the most common causes for an unsuccessful project are changes to the design. Design changes on projects can cost a lot of money and delay the schedule for a long duration, depending on the severity (Sadiq Al-Hejji, 2005). Often times, these changes stem from miscommunications in the drawings or construction documents. While construction documents may seem clear to the parties involved, aspects of the project can be very difficult to visualize. As a result, facets of the scope slide under the radar (Leinonen, 2017). Identifying and correcting these issues is of the utmost importance to the builder because delays have a strong relationship with failure, which may cause the contractors to perform ineffectively (Sadiq Al-Hejji, 2005). One of the techniques that is used by BNBuilders to combat this issue, is their use of virtual reality models, which allow for the parties involved to view the space. The utilization of virtual reality in construction has already shown its worth in the Spectrum/Vertex project that BNBuilders is working on. It has allowed BNBuilders to save time and money on changes by giving the occupants the ability to view their anticipated workspaces (Messner, 2003). As opposed to spending thousands of dollars on mockups in warehouses, they have developed the model complete with different finishes for the owner and occupants to choose from. This paper will expose the costs and the many benefits BNBuilders has attained through their in-house utilization of virtual reality. The Spectrum/Vertex project will serve as a case study to how design changes can be limited through the use of virtual reality.

“BNBuilders is a Seattle based general contractor that was established in 2000 and specializes in life science, biotech, healthcare, education, commercial, public, and office markets [...] For the past 16 years, BNB has experienced consistent growth and reputation for innovative solutions to highly technical issues” (BNBuilders, 2017). After receiving such positive feedback from the Spectrum/Vertex project, BNBuilders' plans to use virtual reality on future jobs.

Virtual Reality in Construction

“Virtual reality has been used within the construction industry for many different applications such as design, collaborative visualization, and as a tool to improve construction processes [...] virtual reality forms a good route for building design as it provides 3D visualization that can be manipulated in real-time and be used collaboratively to explore different stages of the construction process [...] In the future, it may be possible to generate and print 2D CAD drawings directly from the VR models that are being used for architectural design” (Whyte, 2017).

While virtual reality has been introduced to the construction industry in recent years, it has mainly been outsourced to third party companies to produce the models. What sets BNBuilders apart from the competition, is their ability to perform the service in-house. This maximizes profits if done properly because it saves money that would be spent on renderings, mockups, rework, and changes to the design.

According to Senior Project Engineer Evan Horn, virtual reality models are especially helpful for the type of work being performed on the Spectrum/Vertex project. The model saves the project thousands of dollars because it eliminates the need for full-scale mockups of the workspaces. The model provides a detailed representation of what the workspaces will look like and have the specified equipment loaded into it. It gives the end user the opportunity to be involved with the design process and see if any component will be a problem in their day to day activities.

Opinion of Virtual Reality in the Industry

There is no denying the fact that technology shifts, change the productivity of workers. The typical trend of the younger generations is a rise in productivity, and for older generations, is a drop in productivity for older (MacDonald, 2004). “Older workers often find the updating of complex technology uneconomic, while younger workers acquire and readily employ skills tailored to the newest technology” (MacDonald, 2004). This mentality is reflected in the construction industry because many site superintendents are opposed to changing their ways of doing things because they do not want to depreciate their skillset developed throughout their careers.

In the case of the Spectrum/Vertex project, Jim Larsen (Vice President of Vertex Pharmaceuticals) has only a slight exposure to Building Information Modeling (BIM). Larsen thought virtual reality was a gimmick and a waste of his valuable time. With a lack of connection to the construction process, he did not see how the investment would help the project. However, once in the virtual reality model, he realized that a very limited background in BIM was needed to operate the technology. He also identified how spatially accurate it was, and it opened his eyes to lab equipment coordination. Once BNBuilders left the conference room, Jim made sure they received the award of contract due to the utilization of new technology. The virtual reality was referred to as a “game changer” for the facilities management team in the future use of the building. The technology is on an aggressive uphill slope as shown in Figure 1.

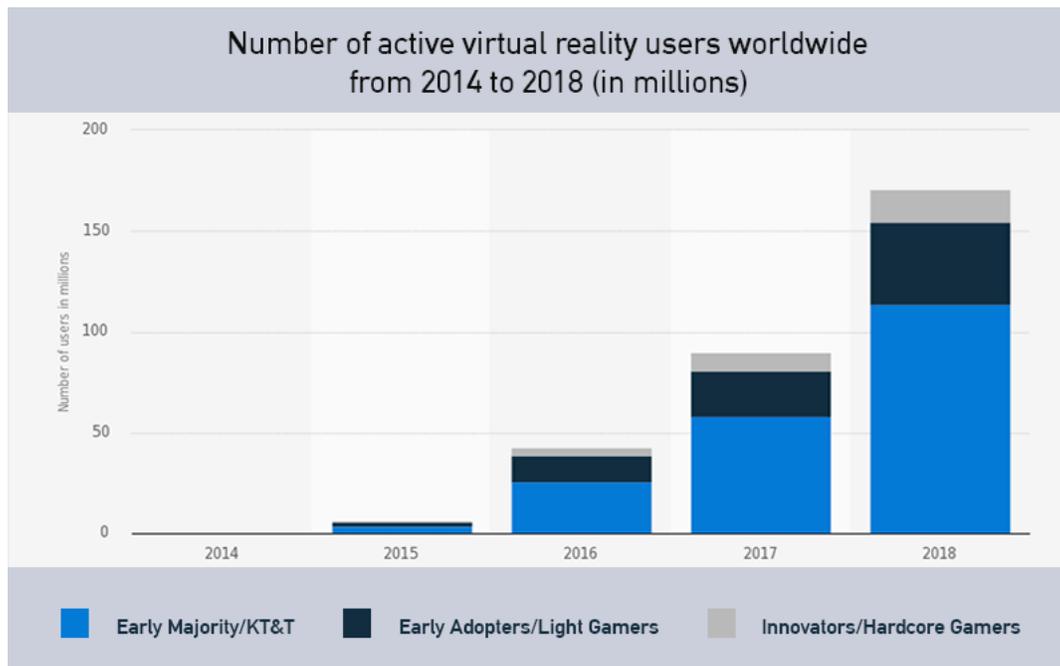


Figure 1: Number of active virtual reality users worldwide from 2014-2018 (in millions) (Cleveroad, 2016)

The addressable market for virtual reality is broken into three different user categories:

- Innovators / Hardcore Gamers: 2.5% of general population
- Early Adopters / Light Gamers: 13.5% of general population
- Early Majority / KT&T: 34% of general population

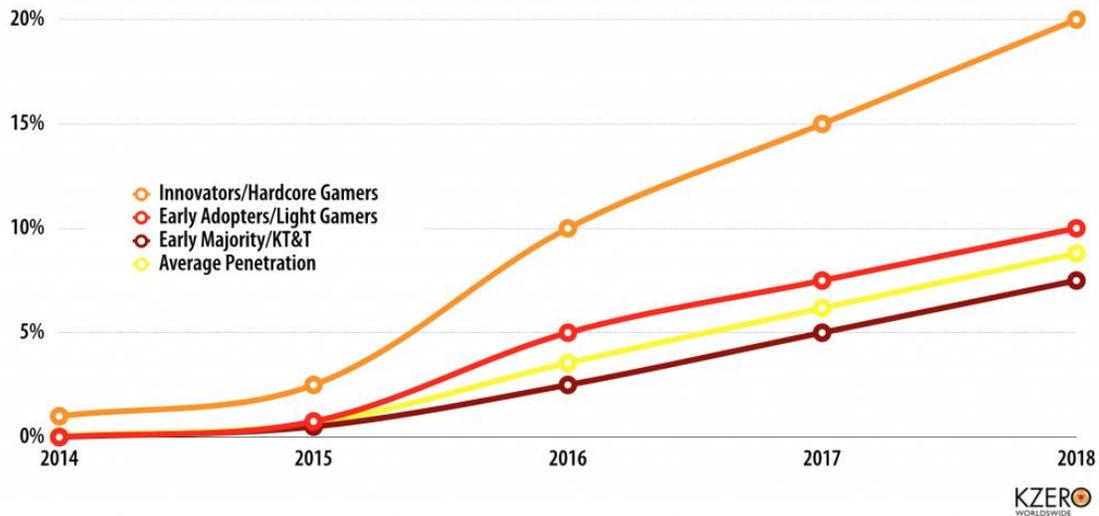


Figure 2: Market Penetration for Head-mounted Displays (Tyler, 2016)

Virtual reality in construction falls into the innovator and hardcore gamer user category which has the highest forecasted growth over the next few years (Tyler, 2016). This trend shows that, while it may seem that virtual reality is just an expensive toy, “this technology can help firms communicate with their clients more effectively, manage expectations, achieve faster project approval, and ultimately improve outcomes for all parties” (eSUB Construction Software, 2016).

The objectives of this case study are as follows:

- Identify the outcomes of the Spectrum/Vertex project with the usage of virtual reality
- Highlight goals of virtual reality in construction
- Touch on the challenges of virtual reality in the construction industry
- Expose the benefits of virtual reality in construction
- Recommend ways to improve the technology as it relates to construction

Methodology

For this case study, qualitative research is the most effective type of research; this is because this case study is founded upon the opinions of industry professionals. Also, this type of qualitative research is more exploratory because of limited knowledge about the topic. An analytical case study will be performed on BNBuilders use of virtual reality for their Spectrum/Vertex project, and display how it helped with securing the project. This paper will also talk about how BNBuilders plans to utilize the technology in their company in the future. The best technique for data collection for this topic will be personal interviews. The information from this case study will be from phone call interviews with:

Adam Gross

Senior Estimator and LEED AP BD+C

BNBuilders

Meredith Stumpo
Evan Horn
Michael Dulberg
Jim Larsen
Danny Campbell

Senior Estimator and LEED AP
Senior Project Engineer
BIM/Innovation
Vice President
Architect and LEED BD+C

BNBuilders
BNBuilders
BNBuilders
Vertex Pharmaceuticals
DGA

Case Study

The Spectrum/Vertex project in San Diego, California was the first time BNBuilders utilized virtual reality modeling for a project. One of the reasons they felt justified to utilize a new technology, was because they were awarded the contract for both the core and the shell. This allowed them to heavily focus on coordination between the two parts of the project, which gave them the opportunity to limit clashes. According to Larsen, this lab will be the “lab of the future” based on the building’s level of sophistication.

Project Specifics

The project details are as follows:

- 290,000 SF steel/unitized glass curtain wall structure with 2 stories of underground parking and 2 stories of research lab space
- Client is Vertex Pharmaceuticals
- Contract cost: \$110 million
- Architect DGA
- Scheduled completion date Spring 2018

Discussion

The information contained in the subsequent paragraphs was obtained through phone interviews with: members of the BNBuilders team, Danny Campbell the architect on the project, and the client Jim Larsen. Discussed below are the goals, challenges, and benefits of virtual reality on construction projects.

Goals of Virtual Reality in Construction

BNBuilders’ goals for implementing virtual reality into their business have led to challenges as well as unexpected benefits. The expectations for producing a heightened level of visualization are as follows:

1. **Gain more contract awards:** One of the core values at BNBuilders is innovation. BNBuilders uses virtual reality to display their values to clients. The use of virtual reality also helps to get more contract awards because it shows that their concern for detail. It allows them to catch any missed details before construction begins versus later in the projects schedule.
2. **Reduction in changes/rework:** The ability to look at the project from different perspectives will decrease rework because most of the design flaws will, hopefully, be taken care of before construction begins. Virtual reality will also help with RFIs because there will be a model to look at for reference.
3. **Save clients money:** By adding virtual reality to their business, BNBuilders’ goal is to save their clients money on renderings and full scale mockups. By having an interactive model there is no reason to spend money on expensive mockups and renderings. BNBuilders will also be able to produce a better estimate because they will have a better idea of what is contained in the project.
4. **Improve Communication:** BNBuilders attempts to improve communication with design by having clients put the goggles on and move around the model. Their justification for using virtual reality is because it

helps clients see what their design is going to look like. Not many owners are proficient enough in BIM to understand what their finished product will be. Virtual reality modeling also helps with subcontractor coordination by identifying locations where they may need to overcome certain obstacles.

Benefits of Virtual Reality in Construction

Due to the infancy of this technology, all of the benefits of virtual reality in construction have not been fully identified. However, thus far on the Spectrum/Vertex project, the benefits are cost savings, design flaw identification, and the use of the model for facilities team management.

From a cost savings standpoint, the virtual reality model saved the client money that would have gone towards making a mockup on exterior metal fins. The fins were a design feature that protruded from the wall and wrapped around the entrance of the building. Instead of spending the money to produce a mockup of the fins, Michael Dulberg was able to load them into the model and give an accurate representation of what the design feature would look like.

According to Larsen, without the virtual reality model he would not have had the confidence to make two costly design decisions. One of the features on the project that he was skeptical about was a large mosaic wall detail. Because of the price tag on the piece, he was not certain he wanted to spend the money on the detail until he saw it in the virtual reality model. Another design flaw that was identified, was an obstructed exterior view due to a piece of lab equipment. The virtual reality model showed what the 2D plans could not. Without the virtual reality model, the feature would have gone unnoticed and rework would have occurred.

One of the benefits that came about later in the project was the idea of using the model for the facilities management team. For many older buildings, it is difficult to locate certain aspects of the structure once the “skin” is put on. With the use of an iPad the facilities management team will be able to look underneath the drywall to identify building components. This will allow them to make live updates to the model if adjustments are made. This will also help help make building improvements more quick and more cheap.

Challenges of Virtual Reality in Construction

Virtual reality in construction has many benefits, however, these benefits do not come right away. This technology is still in it’s infancy and has some hurdles to get over before it becomes common practice in construction. At this moment in time, only a few people in the world of technology understand how to make virtual reality models.

One of the main challenges facing this technology right now is a lack of streamlined software. In order to create a working virtual reality model, the user would need to trim down the Revit model into different file formats so that it can be loaded into a gaming software (Epic Games “Unreal Engine”). Once all of the unnecessary faces are trimmed out of the model, the building faces that the user will actually see are loaded into the software. This allows the file size to be much smaller and creates a smoother experience for the person with the headset on. According to Dulberg, after the Revit model has been provided by the architect, the file trimming process takes roughly 120 hours to complete. Given that this work is done prior to contract award, it serves as a financial risk to go about this lengthy process. If there was a software that “talked” to both Revit and Unreal that allowed for real time edits to reflect on both models, virtual reality would be much more cost efficient and would allow for more people to be able to prepare models.

While virtual reality saves money on changes to design, it has proven to be a double-edged sword from the architect’s perspective. In the case of the Spectrum/Vertex project, Danny Campbell realized that by giving the model to the client and end users, it opened the design up to scrutiny. With scheduling being a very important factor in the success of a project, having many different design viewpoints makes it harder to stay on track with the design schedule. From the architect’s perspective, you want your client to appreciate your design, but at the same time, you want to prioritize the design changes, to the best of your ability, to stick with the schedule.

Conclusions

Construction has proven to be a dynamic industry over the past few decades due to the implementation of different software's. With the addition of virtual reality to the repertoire of tools, it has shown to be a productive utilization of interdisciplinary technology. While the technology still has a lot to improve upon, it has the potential to exponentially increase the integrity of a project from the time, cost, and quality standpoints.

Although the technology is in its infancy, BNBuilders' introduction of virtual reality to their business has already shown the capability to save money, gain more contracts awards, improve communication, and limit rework. Once a streamlined software is presented to the market, BNBuilders' will be able to capitalize on even more profit while maintaining their innovative advantage among their peers.

Future Research

The most productive way to improve this process would be to develop a streamlined software. Currently, a software does not exist that talks to both the Revit and virtual reality models. If this were to exist, the streamlined software would allow a company to capitalize on much more profit and time savings. Right now, most of the time (and money) is spent updating the model to reflect design changes. Once this type of software hits the construction market, the possibilities are endless in the virtual world.

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