Virtual Reality as a Design Tool: A Case Study

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Learning Objectives

- Discover several workflows that have been tested and proven successful
- Get a firm grasp of the strengths and weaknesses of using virtual reality as a design tool in an architectural setting.
- Case studies sharing visuals of our VR builds showcasing real world projects that have benefited from virtual reality.
- Forge your own path into virtual reality, confident that this innovative technology will benefit your firm and your clients

Description

This class will be an in-depth look at one firm’s road into virtual reality (VR) and how we use it as a design tool. The road was unpaved and littered with skeptics and the unknown. Pushing forward led us somewhere unexpected. We’ll run through a case study involving upwards of 10 active projects that benefited from and pushed our knowledge of VR. Using a live Vive demonstration, we’ll go inside these projects and show how they benefited from this new technology. There will be time at the end for questions, and the opportunity for attendees to get hands-on with our builds. This discussion will include a basic understanding of our workflow, translating models from Revit software into 3ds Max software then into the Stingray gaming engine and also Unity.

Speaker(s)

David Hamel joined Payette in 2005 as a 3D Visualization Designer, he now manages the visualization group. He introduced VR / AR development as an architectural design tool and leads the company's virtual reality efforts with a vision to continually enhance the capabilities of the core design team. Using VR to facilitate design discussion and discovery, he has proven VR and AR will play a key role in architectural design as both technologies continue to evolve in the near future.

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Discover several workflows that have been tested and proven successful. Get a firm understanding of the strengths and weaknesses of using virtual reality as a design tool in an architectural setting.

We’re sitting in a DeLorean equipped with a flux capacitor fueled by smuggled plutonium as we’re being teleported back in time two years to the moment before developing VR and AR experiences in the AEC industry was as prevalent as it is today, the following information is what my pre-VR self might find to be valuable information. While traveling our own VR road over these past two years we ran into roadblocks and maneuvered around potholes figuring out ways to advance our virtual reality experiences. Like most roads we travel down in architectural visualization there are multiple ways to accomplish tasks. I am sharing what we found to be strengths and weaknesses based on the type of work we do and our office culture. Depending on your project and its communication needs you will need to decide the correct road for your firm. Static VR vs. Immersive VR. Phone/Tablet vs. Cardboard/GearVR vs. Vive/Rift. There are pluses and minuses associated with this decision. So choose wisely.

Virtual Reality (VR): Hardware and workflows

There are many different workflows for virtual reality currently being utilized in the architectural industry. We will share a few of them here and discuss how my firm has learned to build and incorporate them into our design process.

1. Static VR : Panoramas/360

Panoramas and 360 images are most often displayed on phones, tablets, and untethered head mounted displays (HMD), similar to google cardboard and Samsung Gear VR. Depending on the peripheral you choose you have the choice between a simple 2d spherical image or 3d stereoscopic image.

Spherical Renders:

Spherical renders display cleanly on phones and tablets with accelerometers. This functionality allows the user to hold the device in the air and experience the space by moving the device side to side and up and down. You also have the option to control the display by using your finger on the face of the screen to rotate and scale the image.

You will need to set your camera to spherical.
Workflow:

Once your render is created, upload it to an app that is built for viewing on your chosen hardware.

Stereoscopic Renders:

Stereoscopic images offer a more three-dimensional view. The stereoscopic camera in your 3d rendering software renders out two separate images. One image represents the users left eye and the second image represents the users right eye. The renders are only slightly different. This difference is governed based on the distance between the users eyes. I use the distance recommended by the folks over at Chaos Group (vray), 6.3 cm.

Set your camera to Cube 6x1
Cube map rendered for each eye for cardboard.

**Strength:**

Super mobile, very easy to use, easy to add in to your existing rendering pipeline. Can add in simple adjustments like animating the sun location or setting up design options but unless you find an app that has these functions built in, you will need to build and code this yourself.

**Weakness:**

Not fully immersive. Cannot move through the space and adjust the camera location. Cannot interact with the space and the objects in it beyond gaze-based interactivity.

2. **Immersive VR : HTC Vive**

We use the HTC Vive, but you also have other choices like the Oculus Rift. These HMD’s offer a much more immersive experience, where almost anything is possible. Both of these headsets are currently tethered to computers, although there are third party add-ons being released soon allowing the Vive to become wireless.

- Default view mode is stereoscopic 3d
- Best experiences when using a computer running an above average gaming graphics card in order to properly run your VR experiences.
We chose the Vive because of the room scale mobility and at the time it was the only headset that came with tracked controllers. Room scale allows the user to walk and explore in a real life 10ft. x 10ft. area. Not only can you use the controllers to help you move inside VR, but when you move in real life, that movement is mirrored in VR.

The designated VR space in our office.

VR can cause motion sickness, being able to walk in real life and have that movement translate in VR alleviates some of that concern.

**Our workflows for creating Immersive VR experiences.**

When working in immersive VR, one of the most important factors to consider is frames per second (fps). VR is very sensitive to framerate. The recommended fps you want to aim for is a minimum of 90(fps). It is very important to start off with the structure of your model importing as light as possible. One way to help achieve this is to organize your geometry so that it will group itself by material. For example everything concrete will come into VR as one object, all glass will come in as one object, and so on. If each object came in as separate pieces, the whole system gets bogged down and there is too much calculation for the graphics card to process.
1. **Unity**: Allows the visualization team to customize the VR experience.
2. **IrisVR Prospect/ Autodesk Revit Live**: Plug-n-play interface allows the architectural teams to export their own builds quickly.
3. **Autodesk Stingray/ Max Interactive**: Plugs into our visualization workflow offering a streamlined option for photo-realistic VR.

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1. **Unity Workflows**
Revit to Unity

Export .FBX out of Revit and link into 3d Studio Max. We link the model so it is easy to update later as iterative design changes come along. Once the model is loaded you will need to run a script to convert all the Revit materials to Max standard materials. Standard materials translate better to unity.

This is the script we use: It is not free
http://www.scriptspot.com/3ds-max/scripts/universal-material-converter

UMC material converter script
Rhino to Unity

The Rhino export to Unity can be simpler than Revit in that you have the option to skip 3dStudio Max. That is, as long as your model is clean and built the right way. Be sure that your model is built as meshes. Unity only displays one side of your geometry, meaning you need to make sure all of your normals are oriented correctly. Revit models always translate with correct normals so this is not an issue. The benefit of using Rhino is that you only need to export an .OBJ file and save that directly to your Unity assets folder. In our everyday workflow, we already organize our layers by material and make sure every layer has the appropriate material applied to it. This means any project that wants to be built in VR just needs to confirm their normals are all facing the right direction.

Sketchup to Unity

Sketchup requires a few extra steps to get your project into Unity. In order to force Unity to see your model separated by material you will need to follow a different export procedure. Export your model to a .3DS file format. Import that file into AutoCAD and select ‘split by material’. Explode all the blocks and purge the file. Save as a .DWG file and then link that file into 3d Studio Max. Make sure all the objects are assigned standard materials and then export the .FBX to your Unity projects asset folder.
Building VR in Unity

This is the basic workflow for Unity VR builds that we have found successful. I recommend additional training if you have never used Unity before.

**Lighting:** We have found that our VR builds do not need to be photo real. For most of our VR needs a very simple ambient light and a sun setup works best, we don’t fill our scenes with artificial lighting. This keeps the project simple and optimized. We don’t usually include reflection probes or complex effects. The simpler you keep your project the more geometry you can load into it. We have produced some very large VR builds by simplifying our approach.

**Materials and Shaders:** Similar to lighting we keep materials very simple and the size small. If the map you want to use is not square you will need to adjust it to a square format. We do use bump and reflection maps to more accurately represent materiality.

**Teleportation vs. First Person Shooter (FPS):** Motion sickness is one of the biggest problems developers have to contend with in VR. We experimented with the first person shooter mode of VR transportation for all of 2 minutes. At that time there were only a few options. We tested teleporting and instantly realized that this would be a much better choice. The advantages of teleporting are obvious, a disadvantage worth noting is the way teleporting bypasses the passing of time. We have built several huge projects with expansive sites. I could make an argument that it might be nice to move through the site at the same rate you would walk in real life. This could give the user a truer sense of the sheer magnitude of a project and its site. I feel the developers of Google Earth VR have made huge strides in the first person transport mode. They have limited the amount of image being shown while moving in VR. They also blur the edges of the image almost mimicking peripheral sight.

- Load your models and materials into Unity.
- Download SteamVR from the asset store.
- Download a teleportation package, this becomes your camera. We use ‘VR ArcTeleporter’ found here: [https://www.assetstore.unity3d.com/en/#!/content/61561](https://www.assetstore.unity3d.com/en/#!/content/61561)
• Download a sun and sky package if you want to be able to customize the look of your sky. We use ‘Time of Day’ found here: https://www.assetstore.unity3d.com/en/#!/content/7316

**Entourage:** Duplicate entourage objects like chairs, tables, etc in Unity and not in your 3d software. This will keep the polygon footprint light.

2. IrisVR Prospect/ Autodesk Revit Live Workflows

There are several options on the market for plug-n-play VR. Autodesk offers a program called Live that plugs into Revit as a way to author a VR experience through the Autodesk cloud.
Our firm has found IrisVR to be very versatile and easy to use. IrisVR Prospect plug-ins can be installed in Revit, Sketchup, Rhino, and Grasshopper. Prospect automatically translates your model and incorporates a teleportation system for movement throughout your space. They also have a plethora of additional tools that can be very useful.
A few notable programs that we have tried are Revizto and Enscape. Try out as many as you like to find what fits best for your firm.

3. Autodesk Stingray/Max Interactive Workflow

Stingray is new to us but I feel it is worth mentioning because it is something that can be inserted into most architectural visualization pipelines that use 3d Studio Max. We are still developing a workflow that makes sense for our firm. We have created a few VR experiences using the Vive template that comes included. Our hope is that this will be a great option when we need to create photo real VR experiences.

Open Stingray and start a project using the template that works for your VR hardware.

Send your model from 3d Studio Max to Stingray using the Stingray plugin.

A great tutorial to follow is located here: [http://help.autodesk.com/view/Stingray/ENU/?guid=tutorials_on_area](http://help.autodesk.com/view/Stingray/ENU/?guid=tutorials_on_area)
Strength:

Fully immersive experiences. Ability to interact with the VR environment. Customizable. Explore design options instantly. Room scale promotes real world movement. Greater understanding of scale.

Weakness:

Portability is limited or at least more cumbersome. Need to learn more involved workflows to provide customizable experiences. Cost of equipment is much greater especially if interested in providing mobile immersive VR.

The workflow you choose will depend on your project and its communication needs. If we need more control and a customized experience, we choose Unity. If we just need something fast and easy, a plug n play software like IrisVR Prospect might be the best choice. For photorealistic builds, we are looking for Stingray (Max Interactive) to give us the quality we need.

Case studies sharing visuals of our VR builds showcasing real world projects that have benefited from virtual reality.

Virtual reality is a great tool for presentations, a way to communicate designs to clients. We’ll now discuss and show how VR can benefit project teams throughout the design process, from initial massing studies all the way through CD’s.

After you start developing for VR I recommend inviting as many people as possible into your VR builds, as often as possible. Having a wide range of users interact with your VR experiences will
inform your future builds. This will help you understand what works and what doesn’t. A lot can be learned that will help shape the way you approach your future VR experiences.

**Keep It Simple**

As mentioned earlier, one of the most surprising things we learned and it still surprises me sometimes today, is that architects and clients alike do not need a photorealistic VR experience. Anyone working in visualization inside an architectural firm knows that sometimes less is more. A simple stylistic render does a great job expressing the design. Not showing the exact look of the proposed brick or the exact materiality of floors and walls keeps the focus on the overall design. The client is not getting distracted with design criteria that is not ready to be decided and has not yet been explored.

![Image](image_url)

**Lets Not Go Fishing**

Something as simple as the way users hold the VR controllers can drastically effect their experience and of course your ability to communicate your design. We noticed that many people will hold the controller vertically, similar to the way you hold a fishing rod. This is a problem when teleporting in VR. The landing point for the teleporter ends up so far away the user either no longer understands where they are, or they accidentally drop themselves inside objects unintentionally. The user ends up lost and confused. Addressing this in your pregame instructions before the user puts the headset on, along with anything else you’ve seen create confusion, will keep the design discussion on track and focused.

**Rendering Level**

Most of the materials in the following image are simple and nondescript. A few select materials like the corten steel on the bridge guard rails were important to express the design.
Case 1: Northeastern University

When we first started getting into VR, we did not yet know how valuable it would become as a design tool. The experience we created for this project was initiated as a way to communicate design ideas to the President of the university. The power of VR as a design support mechanism became clear the very first time one of our architects tried it out.
One of the early concerns was how effective would this medium be to senior staff. This project quickly put those concerns to bed and became one of the projects we learned the most from. Having forced us to develop tools for customizing the experiences we build. In order to create customized tools, we needed to learn some basics of coding and receive a lot of outside coding help.

Respawn

One of the first scripts we wrote was the ability to reset the users experience if they get themselves lost in the model. As time went on we adjusted the way we built our VR experiences but this was our stop gap solution. Users would, on occasion, lose themselves in the 3d model they were exploring and talking them through an exit strategy was difficult. Our solution was to assign a keyboard stroke that would send the user back to the start position.

ON/OFF

The first script we wrote to help show design options was a super simple script we named ON/OFF. By pressing a preset keyboard button we could show the user two options for a given design live while they were in VR. This script simply turned off one object while simultaneously turning on another object. As an example, we had two guardrail designs (shown below) for a pedestrian bridge that we needed to analyze in-house, and later show to the client.
Sun Interaction

After one of our client showings a request came in for the ability to scroll the sun throughout the day to see how the sun and shadows impact the building and site. With the help of an outside developer (Maxim Antinori) we were able to assign one of the Vives buttons to do what we wanted. This was our first time customizing controller buttons.

Case 2: College Classroom Building

The team working on this project were the earliest adopters of virtual and augmented reality in our office. They were the first to use AR, sharing with clients massing models composited onto site plans. We used colored site plans as AR trackers. The client found it interesting but it was in no way a game changer. The use of AR as a design aid did not have the impact we hoped for. As AR technology continues to progress we will definitely be incorporating more augmented experiences.
VR was implemented for the project team to double check their designs as soon as iterations were modeled. They found VR aided their design workflow in a few ways. In some instances there were parts of the building design in which the team felt they finalized a specific design idea. For instance several aspects of the buildings atrium were continually updated in VR as the team reworked specific details. This is an instance where VR was used to confirm a design strategy. On the other hand, they also studied, through renderings and in app visualization, specific aspects of design that did not seem to work well. VR was used and confirmed the design worked after all. One of the exterior façades, as it was represented in renderings, was continually scrutinized and thought to not fit. Something as they analyzed it on screen just didn’t seem to work. By chance, they decided to take a look at it in VR and found just the opposite was true. The design at 1:1 scale worked very well.

Starting in schematic design the team used VR to work through dozens of design iterations for the buildings atrium space. Before and after images shown here.
During the duration of the project the team also asked us to add in MEP geometry like piping and HVAC ducting that is exposed in the atrium to review its visual impact.

Case 3: Office Building

We built a very detailed VR experience for a prospective client. Taking notes from previous VR builds, we learned a great deal and wrote a few more scripts to allow the user to control and interact with the experience. In order to help guide the users experience we setup boundaries for where we allowed them to travel. We also advanced our ability to show multiple design options seamlessly inside VR.

Boundaries

During previous VR client showings we learned that we needed to develop a way to limit where the user could travel. There were occasions where users would teleport themselves outside of the area of focus. They would sometimes get themselves lost and we would have to help them find their way back, or click our ‘respawn’ button to push them back to the beginning.

We devised a simple way to let them only go where we wanted. In a game engine there are many ways to do this. As a visualization group, who are not true developers, nor should we be, we choose to keep things simple whenever possible. Developer compatibility is so important. If team members leave or rotate over to the architectural studio, which happens, we design our workflow so new members can still contribute.
In order to teleport throughout the space, you need to attach a collider to your floors, sidewalks, stairs, etc. By breaking up the geometry in the 3D package before it makes its way into Unity we give ourselves the option to attach colliders to specific parts of the floors, specific sidewalks, specific stairs or no stairs if we don’t want them changing levels. This way the user can only teleport through the spaces that contain floors with colliders attached.

Orange boundary is limit of travel.

**Toggle Design Options**

This project brought on a new problem that needed to be solved. We started to touch on this issue with the ON/OFF script, but this problem required much more of an elegant and advanced solution. We needed to allow the user to scroll through three separate design iterations without having to come out of the VR experience. We succeeded by building one script that did many things. And all with a press of one button.

First we set the script so, with a click of a button on the controller, the user turns off the current level while simultaneously loading the next level. There were three designs so the new levels needed to load in succession. Each level was a whole new design option with its own set of entourage and materiality. The three levels were all located next to each other in 3D space so we also wrote into the script that as the levels were loaded and unloaded, we moved the game camera position over to that levels location.
The images below share a glimpse of how the script functions attached to the Player and what the three designs look like in 3d space.

Case 4: Hospital

Full Site VR

This project is by far our largest build to date. All the lessons learned during previous builds as to why you optimize geometry and limit lighting and reflection calculations pays off on a project like this. The project specs are as follows: Site is almost 30 acres, 5,600,000 Sq. Ft., 2500 patient beds, 50 OR’s. The 3d model totals 11,586,148 triangles (2,519,378 polygons).
Our architects needed a way to show five possible façade design options, and a way to communicate them to the local architect overseas. They built 3d mockups of a specific section of the building. This included five facades that were being proposed. We used our Toggle Design and Node teleport scripts to allow the user to scroll through the designs while in VR. We also assigned a controller button to move the camera to predefined spots inside the building on each floor so they could experience the effects of the facades from within.
Object Interaction

We built a script that allows us to assign objects with the ability to be picked up and moved by the VR user. We can see an opportunity for users to take advantage of this during studies of spaces like OR rooms, patient rooms, etc.

Live Annotation

We built a script that allows users to sketch in VR. And an added capability of drawing on structures within the build such as walls, doors, etc, as an additional way to communicate design changes.

Forge your own path into virtual reality, confident that this innovative technology will benefit your firm and your clients.

If you’re like me, your primary responsibility at the office is not VR. There is an inherent struggle to create time and opportunity to initiate R&D for an untested new medium. Hopefully the info I’ve shared helps you choose a path into VR that works for your firm. After VR is proven valuable there is now a need to keep your foot on the gas while balancing all your existing deadlines and responsibilities. Easier said than done.

Choose your path to VR. What are you hoping to achieve?

- Design tool
- Presentation tool
- Fundraising tool
- Communication tool
What software/hardware combination fits your needs?

- Static: phone / tablet / cardboard / GearVR
- Immersive: HTC Vive / Oculus Rift
- Unity / Unreal / Stingray
- IrisVR / Revizto / Enscape3d / Lumion / Twinmotion etc

The Design Conversation

Below we see a photo of a typical studio pinup of a project in the early stages of design. Below that is a photo of a group of people taking turns experiencing VR discussing design. Both conversations are incredibly valuable. They provide a different way to communicate design. Soon, we will have multiple HMD’s running at the same time.

Classic design conversation: Studio pinup.

VR design conversation.
Fundraising

Panoramic / 360 renders and simple augmented models are very mobile friendly which make them great options for institutions needing to raise funds or sell / lease space.

Be Over Prepared

When taking VR on the road be over prepared. We own two Vive systems. One has a permanent home in the office. The second lives in a large suitcase with tripods, cables, extension cords, adaptors, power strip, and flash drives. We have multiple sets of cables and multiple sets of extension cords. We seldom use the extra hardware, but we have it just in case. Be sure all your software has the latest update installed. Confirm your headset, controllers, and light houses have the current firmware updated. Forgetting to update software and firmware means you will have to do it on site which can be a timely process. You don’t want to show up at your clients office and not be able to run the VR experience that you’ve been spending days building.

Things change fast, keep up.

New VR and AR technology and software is being announced all the time. It’s important to keep yourself informed with the latest and greatest. Follow as many related news organizations as possible. Here are a just a few:

Linked In group: Augmented Reality (AR), Virtual Reality (VR) & Virtual Worlds (VWs)
https://www.linkedin.com/groups/37782
Linked In group: Augmented & Virtual Reality Professionals
https://www.linkedin.com/groups/67494

Linked In group: Virtual Reality – VRTalk.com
https://www.linkedin.com/groups/8494822

Linked In group: Enterprise Wearable Technology
https://www.linkedin.com/groups/8262990

Linked In group: Virtual Reality (VR) & Mobile Learning Forum – The Leadership Network for Business Training
https://www.linkedin.com/groups/8488439

Linked In group: Mixed, Augmented and Virtual Reality in Architecture, Engineering and Construction – AEC
https://www.linkedin.com/groups/8364351

Linked In group: Virtual Reality News
https://www.linkedin.com/groups/8452677

Facebook group: Architecture VR (AR/MR) – Cgarchitect.com
https://www.facebook.com/groups/architectureVR/

VR Voice
https://vrvoice.co/

Opportunities Beyond Architecture.

Volunteering

Christopher’s Haven: “A home for kids when cancer hits home”
http://christophershaven.org/

Christopher’s Haven is a home away from home for children and their families while they are receiving treatment for cancer. We bring our mobile VR setup to them a couple times per month after hours and give the kids and their parents a fun way to break away from their stresses. Read more about it here: https://www.payette.com/cool-stuff/introducing-vr-to-the-families-of-christophers-haven/