

# 3D Virtual Learning Spaces

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Learning within the construction industry is challenging due to the complexity, size and variety of construction projects. This project aims to tackle these challenges through the use of 3D modeling and VR technologies. The project focuses on the teaching of structural steel framing with an emphasis on the stages/phases of construction. The first steps involved taking structural steel plans and using them to create a 3D model in Revit. The model is broken up into stages from foundation to roof framing to highlight the stages of construction. Once each model stage was finalized, it was imported into a 3D program called Cavnus that allows for both VR and AR functionality. Each stage of the model was placed into the space with an accompanying PDF of the plans used to create the model. Some details from the plans were also placed in the space in PDF next to where the detail was modeled. Lastly, a welcome board with directions for the space and tips for moving around the space. This space is now ready to host classes where students are able to explore and ask questions about steel framed construction from their computer.

**Key Words:** 3D Models, Virtual Learning, Virtual Reality, Structural Steel, Cavnus

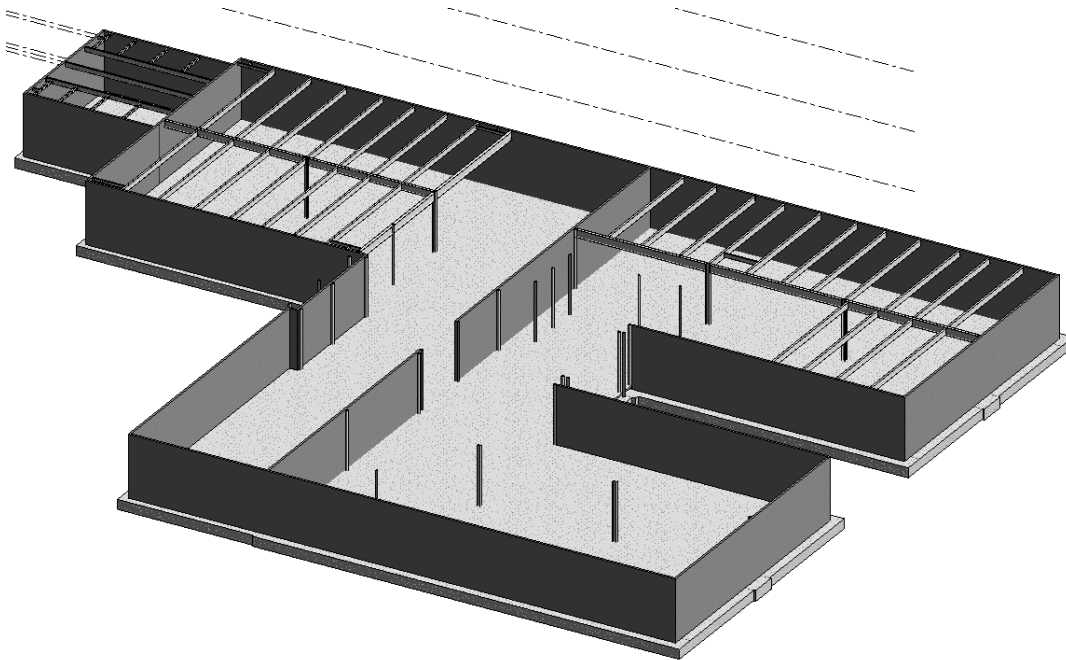
## Introduction

This project idea was brought up by Andrew Kline as he talked about ways the construction industry and Cal Poly could use the upcoming virtual reality (VR) technologies. Andrew also brought up Cavnus, a VR and augmented reality (AR) software that can have 3D models imported into it. Cavnus uses what are called “spaces” which are where the models get imported into and within these spaces you can have video calls going with everyone in the virtual space. Cavnus can be used with VR and AR but still function well when just using a computer. With this technology, there is an opportunity for utilizing this technology to help teach construction to students. Learning construction can be difficult without a visual reference as many aspects of a building are never seen by the normal public. This led to the idea to create a visual learning opportunity for people using Cavnus and the VR technology. This learning opportunity would be for structural steel as this is something that cannot be seen in most buildings and is hard to provide good visual for teaching structural steel. The learning opportunity will be a Cavnus space with multiple 3D models of structural steel framing with accompanying PDF of plans and details used to create the models. This Cavnus learning space will be the final deliverable for this project with the hope that this spaced will be used by the industry to

help teach the next class of construction managers. There is also a hope that more of these learning spaces will be created to continue to raise the level of education offered for construction managers.

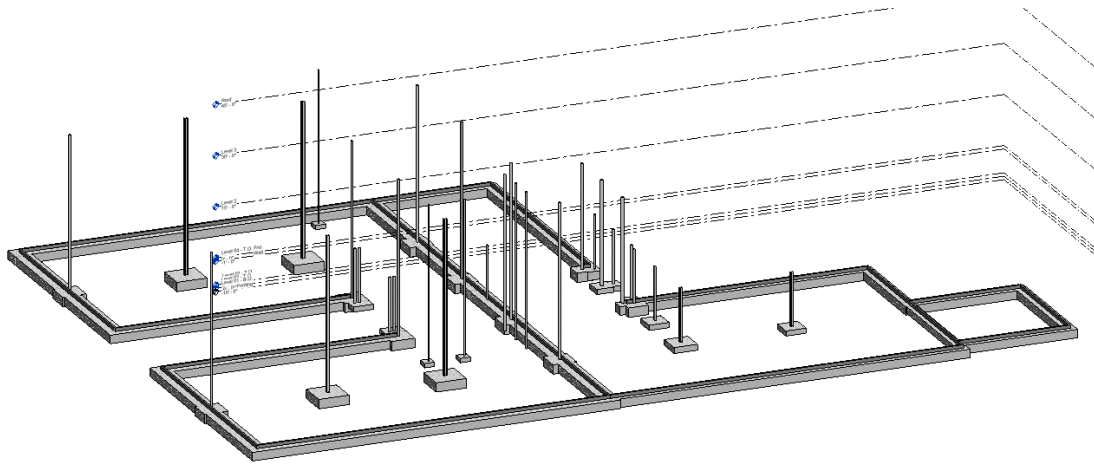
## Methodology

To create the learning space in Cavnus, the first step was creating a 3D model of structural steel framing that will be used as the foundation for learning in the space. To create a good education model, real structural framing plans from an actual project in Orange County, California. Utilizing Revit, a 3D structural steel model was created from the plans. The model included all structural steel elements as well as concrete foundation and structural walls. The model encapsulates all structural elements for the building for a full scope learning experience.



*Figure 1: Creation of the 3D Model in Revit*

Once all the elements from foundation to roof framing were finished the model was broken down into four different stages of construction. These stages went are foundations and columns, second floor framing, third floor framing, and roof framing. This separation was done in order to show the steps of structural framing from foundation to roof. To separate the models, four separate model files were created from the original model, one for each stage. Then elements were deleted from the model so that each model only had elements that were within its stage. For example, the foundation and columns stage, as shown in figure 2, only have foundation and columns and all other elements were deleted. The other stages were also created accordingly with elements only up to their stage in construction.



*Figure 2: Foundation and Columns 3D Model*

Once all these model stages were complete, the next step was to insert these models in the Cavnus space. To do this, a space was created in Cavnus and a showcase building was placed in it in order to hold the models and contain the space to a smaller area. Then each model stage was exported as an FBX file and then inserted into the space. Once in the space, the model needed to be scaled properly and colored so that the steel and concrete can both be easily identified. This needed to be done with each of the stages of the model. The models were then arranged in the space so that each stage had its own corner in the space. Each model stage was also accompanied by the PDF of the plans used to create that model stage. For example, the second-floor framing model stage has the plans for the second floor framing next to it, which can be seen in figure 3 below.

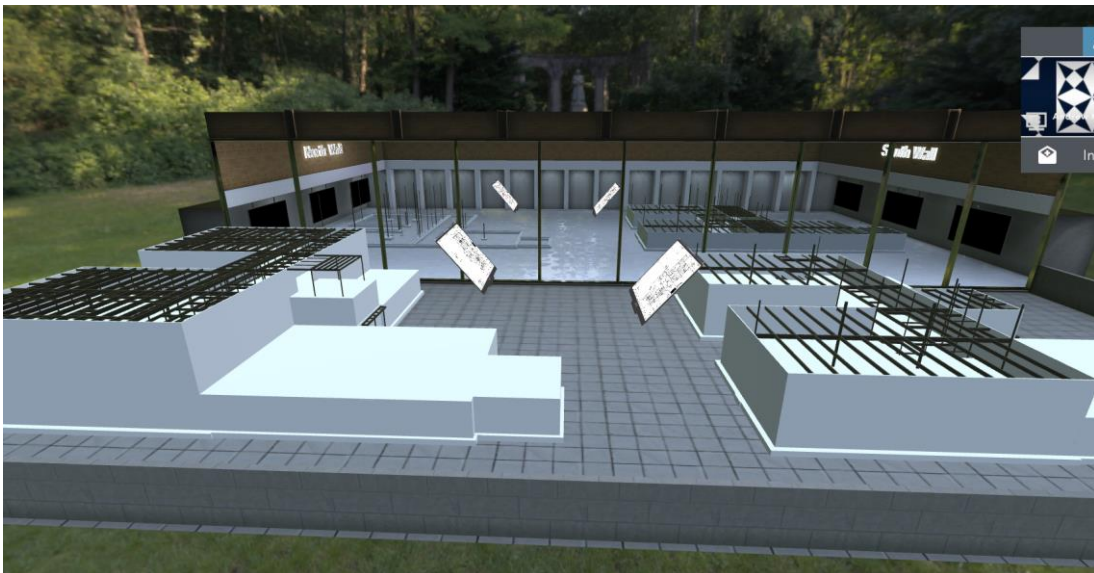


*Figure 3: Second-floor Framing Model and Plan*

With the models and their associated plans in the space the majority of the work is done. The next steps include adding some PDF of details into the space. A PDF for a detail for a column footing was placed next to the column footing of that detail in the model. Although these details are not always modeled, having the PDF of the detail next to the model can help people understand what the detail is saying. The last step is adding a welcome board to help people navigate the space before the space was finalized. This welcome board will have tips for moving around the space and will give a description of the layout of the space as well.

## Deliverables

The final deliverable for this project was a 3D space in Cavnus that can be used to teach structural framing. The space consists of four stages of a structural steel model with associated plans and details to accompany them. Virtual reality and augmented reality can both be used with the space, but virtual reality was the focus when building the space. Keyboard and mouse controls also work in the space if virtual reality goggles are not available. The space can be joined by a whole class of thirty student and a teacher and communication can happen in the space through the video call system. This means the space can function like a classroom but with the added benefit of having a visual aid to reference. Optimal learning for this space will require a teacher to help answer questions from students as the model does not provide the explanation of how the framing works other then the plans and details.



*Figure 4: Overview of Learning Space in Cavnus*

The next steps for this space will be to have Andrew Kline, or another teacher, take a small group of students into this learning space for a trial run. Taking this smaller group will give the teacher some time to learn the space themselves and the students can also provide insight into the how they would want to be taught in this space. Then, after this trial run and after a few teachers have gotten comfortable using this software, this space could be utilized in courses like CM 313 (Commercial Construction). Also, a teaching guide could be created for this space after the trial runs to try to help others feel able to teach in this space.

Hopefully this space can inspire the creation of other learning spaces developed from real world models and plans. MEP spaces could be made to look more in depth at how these systems function as a whole and how the systems interact with each other. Wood framing for residential construction is also an option, which has many different methods and techniques that can be shown. The learning space does not necessarily need to be focused on one part or system of the building but could be a learning space dedicated to an entire building. The teaching capabilities of these learning spaces is very high and will only be limited by what we can imagine.

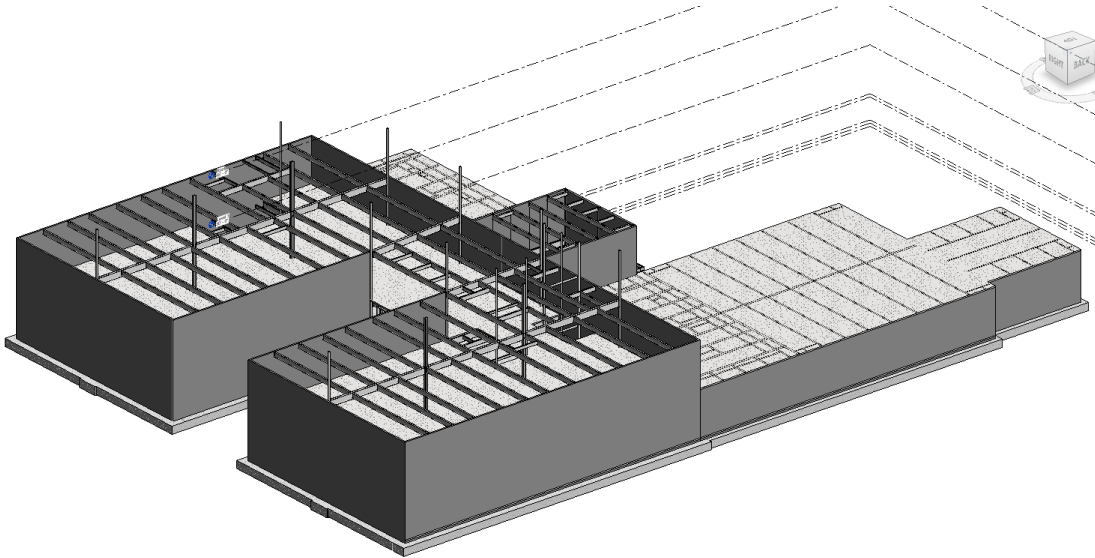
## **Lessons Learned**

This project had many challenges throughout this project that pushed my knowledge of both construction and technology. The first major challenge had to do with the creation of the Revit models according to the plan set. Keeping in mind this model was to be used for learning purposes, the model was not to be overcomplicated. For the best learning, the model needed to be simple but still encapsulate the complicated nature of structural steel construction. This thought process led to the removal of some items from the plans and some simplification of other items. The model also needed to be visually appealing and visually clear and concise. This meant excluding elements that may block the view of the structural steel elements like the roofing, flooring, and interior walls. These were also some of the reasons multiples stages of the model was used so that all elements are easily visible in at least one model. This challenge was a lesson in how best to communicate complicated topics in a simple way. Another challenge of this project was importing the models into Cavnus because elements cannot be colored individually which meant the models had to be broken up into their different colored parts before importing them. Luckily, the only two colors needed for this model were for concrete and steel. This meant each model was broken up further into a steel only and concrete only models for each stage. The models when brought into Cavnus and properly colored then had to be perfectly aligned. This challenge helped grow the understanding of this software and forced outside of the box methods to be used. The final major challenged encountered during this project was how to properly scale the size of these models within the space. The scaling for this space needed to be big enough for easy visual consumption but also small enough to be able to move around the space in a quick manor. The scaling affects the speed you move in the space because you always move at the same speed but if the models are scaled larger it will take more time to move around it then if they were scaled down. This issue required many different scales to be used in order to find the best scale for this space. The scale that was settled on allowed for a better visual size with a slightly slower movement speed around the space. This challenge pushed the understanding of visual communication and forced the focus on how the consumer will use the product. Overall, this project's challenges provided lessons in visual communication, simplifying complicated topics/ideas, and thinking outside the box.

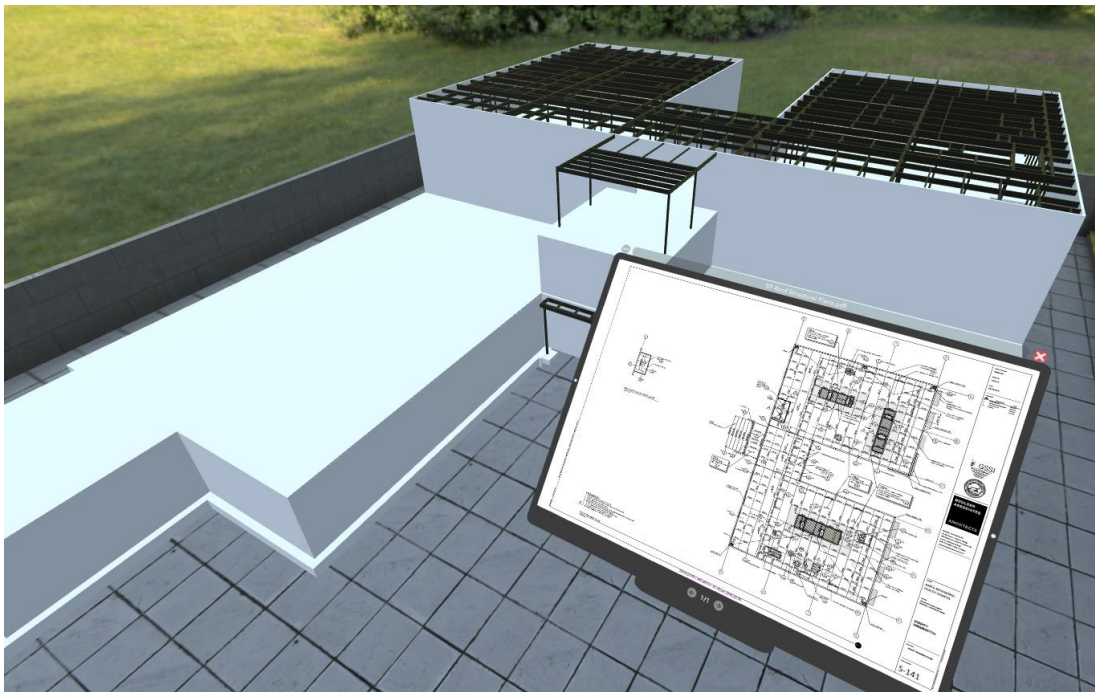
## **Conclusion**

This project sought to create a 3D virtual learning space that can be used as a visual learning tool for years to come. The project also hoped to be the first of a long line of learning spaces that will become the future of construction learning. These virtual learning opportunities will not only benefit Cal Poly but also other schools that may not have an in person building aspect in their curriculum. The virtual aspect also means these learning spaces can be joined from all around the world and provide people with real life construction experiences. Overall, this project created a virtual learning space that may become the future of construction teaching.

## Appendix



*Figure 5: 3rd Floor Framing Model in Revit*



*Figure 6: Roof Framing Model in Cavnus*



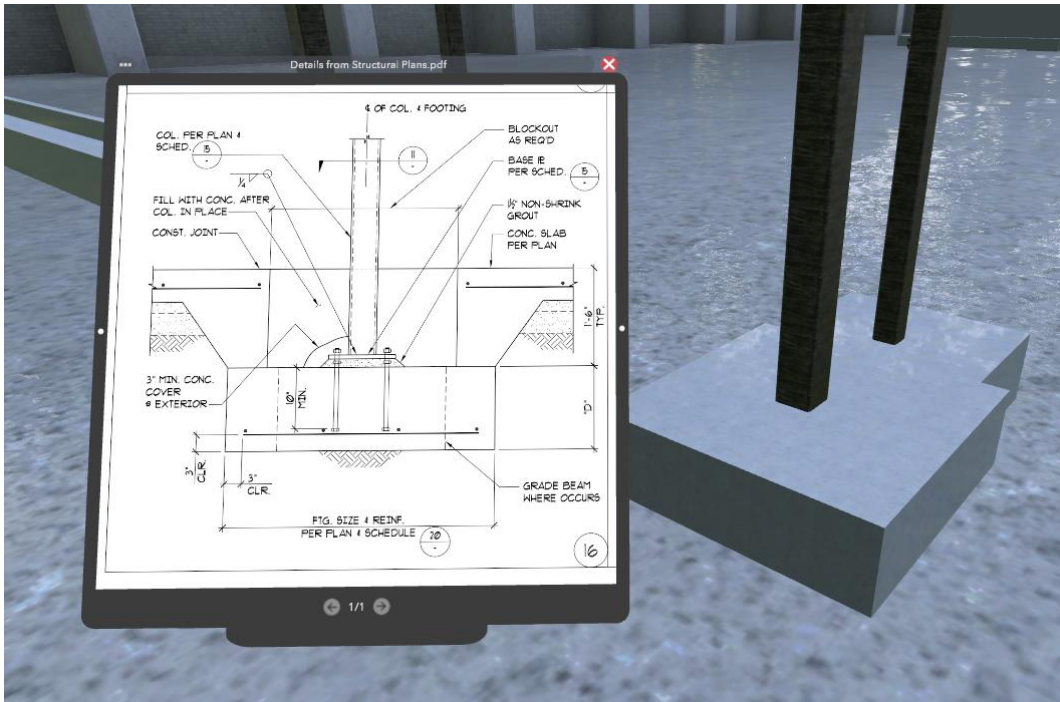


Figure 7: Detail PDF next to Detail Location in Cavnus

**Welcome to the 3D Learning Space for Structural Steel Framing**

This space has four models to depict four stages of steel framing. These models are listed here with their location (North and South walls are labeled):

<p><b>Foundations and Columns - North Wall Inside</b></p> <p><b>2nd Floor Framing - South Wall Inside</b></p> <p><b>3rd Floor Framing - South Wall Outside</b></p> <p><b>Roof Framing - North Wall Outside</b></p>	<p>You are here</p>
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**Helpful Tips**

- Use shift to move faster if on
- Top right of your screen are the video call controls
- Double click with your mouse to quickly move yourself to that location
- More tips and shortcuts can be found in the top left drop-down menu

Figure 8: Welcome Board in Cavnus