Potential of VR 3D Modeling in the Classroom

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Abstract

Many different industries need educated college graduates with 3D modeling experience, such as game design, animation, engineering, and architecture. However, 3D modeling tools can be difficult to learn, and students focused on learning a specific tool may not be able to effectively learn 3D modeling best practices. VR modeling tools are designed to be more intuitive and easier to use, so they may be effective tools for preparing students for work in their industry. This literature review examines the role that VR 3D modeling tools might have in a classroom setting along with instruction on industry-standard tools.

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1. Introduction

As commercial virtual reality (VR) hardware and software has become more widely available, researchers have been attempting to find use cases for a technology that offers a feeling of presence inside of a world, rather than a flat representation of a world on a computer screen. One area which has showed promise over its more than 30-year research history is 3D modeling in VR. Rather than relying on a 2D screen manipulated with keyboard and mouse by the user, VR invites users to look around and manipulate their model in virtual space. Theoretically, this would provide users with a greater ability to perceive the correctness of their models, more precision in model manipulation, and an easier learning curve than conventional modeling tools. If VR 3D modeling tools provide an easier learning curve than conventional modeling tools without sacrificing the model-creating ability of conventional tools, then they may provide benefits for students trying to learn effective tools and techniques for 3D modeling. This literature review intends to evaluate the scope of learning possibilities for 3D modeling tools and provide both recommendations for educators in their fields along with recommendations for future research in the applicability of VR 3D modeling tools in the classroom.

2. Historical Background: 1990s to 2020

For over 50 years, software and hardware developers have attempted to implement 3D modeling software in VR. While there are multiple use cases for VR, research on 3D modeling in VR remained relatively stable from the 1990s through the 2010s (Berni & Borgianni, 2020). Head mounted display (HMD) technology was only one way to provide VR experiences to users. The CAVE system allowed users to stand in a room where projects interpreted by 3D glasses

moved in response to their body movements, circumventing the need for bulky computer hardware attached to the user, but still requiring physical set-up of the system.

Early work in VR tools was defined by struggles to implement hardware that provided enough mobility to take advantage of the advantages of those tools, finding use cases where the limitations of performance, and determining the different types of VR capability. The early periods were categorized by attempting to identify key interface and manipulation requirements in the virtual space. In 1992, The 3DM system intended to replicate the ease-of-use of 2d drawing but was hampered by the bulky hardware requirements necessary to implement the software (Butterworth et. al, 1992).

As hardware performance improved and the scale of VR tools were made smaller to provide more mobility to their users, there was a splintering of VR implementations across many different researchers. This meant that new VR systems were being created by researchers to test particular use cases, but because there was little reuse across researchers, each experiment struggled to match the feature capabilities provided by more traditional modeling software, whether developing software for industrial design purposes (Ye & Campbell, 2006) or artistic design purposes (Jackson & Keefe, 2016).

The release of the Oculus Rift in 2016 marked a third shift in VR modeling tools to focus on head-mounted displays and commonly shared commercial platforms. Instead of developing custom hardware and software solutions, researchers in this era focused on using existing hardware, such as the Oculus Rift or HTC Vive, as well as existing software applications to test the efficacy of VR approaches to modeling, whether applied to improvements in classroom learning (Sopher et. al., 2019), ease of use (Huang & Lee, 2019), or industrial applications (Lawson et al., 2016).

3. 3D Modeling Overview

3.1 Types of 3D Modeling

Different methods of modeling are used to satisfy different use cases. There are two different comparisons which are relevant for discussing 3D modeling tools, parametric modeling compared with direct modeling, and vertex modeling compared with sculpting.

3.1.1 Parametric Modeling

Parametric modeling involves creating a specific design for a model and then building the model based on those specifications. It records the history of users' actions, so that changes made to the model are stored and can be retrieved and updated later as more features are added to the model. This allows for modelers to go back through the history of edits for the model and make a change that will propagate through all future changes of the model. (Alba, 2018).

3.1.2 Direct Modeling

Direct modeling involves editing the model without a feature history. It offers modelers a great amount of control over how the finished model will look, but can also take a great deal of time, and if changes need to be made to earlier parts of the model it can be difficult for modelers to be able to make those changes without restructuring other parts of their model.

3.1.3 Sculpting

Sculpting allows users to mold their model as if it were clay with a variety of tools. They can create clay in the VR space and move and smooth the clay to get their desired model. Sculpting allows for greater speed of model manipulation with the sacrifice of manipulation of individual vertices that is provided by direct modeling.

3.2 Modeling Style Focus Areas

While there is overlap between all types of 3D modelers, there are two different primary purposes of modeling. One approach to a purpose is a focus on accuracy of the model. This focus is often used in fields such as architecture and product design, where models need to follow specific guidelines and achieve objectives based on more exact measurements, even though there may be some creativity in how those goals are reached. In research to determine the applicability of VR, architecture and product design require students to follow these types of guidelines. However, research also takes place for artistic purposes as well, such as creating sculptures in VR and using VR modeling tools to create game assets. These areas focus more on expression, even though there may be some guidelines that need to be followed to complete the model.

These different schools of thought on modeling come from different directions. The design focused modeling school will often start with parametric modeling, and then move into direct modeling when more control is needed to finalize the design. On the other hand, the expressive school of modeling will often start with sculpting and then use direct modeling techniques to finish the models and make them ready for implementation into games or animations.

3.3 Types of Knowledge: Procedural and Strategic

In 3D modeling practice, two types of knowledge need to be conveyed to students. The first type of knowledge is procedural knowledge, which involves teaching students the specific commands to create a model using the software provided. The second type of knowledge is strategic knowledge, which involves the planning of the modeling session as well as following best practices and rules of design intent to ensure that the model is reusable and updatable later in the modeling process (Garikano et al., 2018). These two types of knowledge can be taught

simultaneously, although strategic instruction may not be as effective for students who are already familiar with the procedural aspects of the modeling software before the instruction session (Chester, 2007).

4. VR Modeling

4.1 VR Modeling Tools

One of the barriers present in the past which prevented VR modeling tools from obtaining relevance in a curriculum was the lack of commercially available hardware and software. With the spurring of commercially available hardware after the launch of the Oculus Rift, 3D modeling instructors no longer need to construct their own custom 3D modeling solutions to use HMD VR modeling in a classroom environment.

There are two types of commercially available HMD devices, those that connect to a computer to power the VR system and those that rely on android phone hardware. PC-enabled VR requires a powerful computer to run the VR software through the headset, while android-powered VR can run without an attachment to a computer. Most android-powered VR systems have been discontinued except for the Oculus Quest, while the three major PC VR systems are the Oculus Rift, the HTC Vive, and the Valve Index.

VR modeling tools can usually support both the design approach and the expression approach, although they are usually marketed to one audience or another. The VR modeling tool Gravity Sketch describes itself as “an intuitive 3D design platform for cross-disciplinary teams” (Gravity Sketch, n.d.) to appeal to designers creating consumer products. On the other hand, Adobe Medium is described as a way to “quickly and easily create 3D objects and expressive works of art” (Medium by Adobe on Oculus Rift, n.d.) with an emphasis on portability into game engines and other programs. Google Tiltbrush also emphasizes portability into the Unity game

engine along with a focus on creativity rather than specific design purposes (Tilt Brush by Google, n.d.). Google Blocks provides a simpler interface with a focus on creating more precise 3D models, allowing for better export and manipulation in other conventional modeling programs (Dale, 2017). Any attempt to teach 3D modeling with VR tools in the classroom would need to select a tool that fits the use case for the class, and would need to determine whether exact surface manipulation is required or a gestural sculpting or painting approach will be sufficient for instructing students.

4.2 VR Modeling Research

Both different schools of 3D modeling have attempted research to use VR 3D modeling to improve the 3D modeling process. In education contexts, building models based on concept drawings is important for both the design school and the expression school. Freehand VR modeling tools provide sketch capability inside the tool, but this can be augmented by VR tools which allow users to build models more directly from their sketches (Jackson & Keefe, 2016).

4.2.1 VR Modeling in the Design School

Design school researchers often look to improve on existing CAD tools. VR can often be a complement to traditional design activities, such as the review of in-progress models. Design critiques that take place in an immersive VR environment produce more social learning outcomes than critiques that take place on a computer screen (Sopher et al., 2019). VR has the capability to encourage more social interaction among students so that more collective knowledge is gained, rather than just individual knowledge. However, because designers come from environments with the extensive features provided by CAD tools, they sometimes find the lack of functionality in VR tools lacking in comparison, preventing them from providing an adequate replacement for conventional tools (Ye & Campbell, 2006). In addition to functional

features adopted from CAD tools, the design industry can sometimes have more focus on expanding functionality for VR systems to feel more like the physical product development process with features like haptic feedback (Lawson et. al., 2016).

4.2.2 VR Modeling in the Expression school.

Game development and animation are two areas where an expression-based approach to 3D modeling is needed to create characters and settings for interactive games and animated movies. Because these users are more likely to use sculpting techniques when creating 3D models, VR modeling tools which provide sculpting functionality are preferred. In addition, for game development users often use a variety of tools to edit the models after the initial sculpt, so VR tools need to provide good export functionality in formats that can be used by those other tools (Hurd, 2019). The ability to provide flexibility to go from a fluid hand-drawn concept to a model is also an important part of the expression school, one that can be made easier through both freehand drawing using 3-axis VR and ways to link 2D sketches to the VR space (Jackson & Keefe, 2016). For animators creating VR content, VR tools allow them to experience the animation closer to the way the viewer will experience the finished product (Berford et al., 2017).

5. VR Modeling Implementation Key Questions

With the different use cases for 3D modeling and different types of 3D modeling techniques and tools available, instructors will need to determine whether VR modeling tools provide enough capability for use in their classroom to produce projects comparable to conventional 3D modeling tools as well as the knowledge acquisition effects of VR 3D modeling tools.

5.1 VR Modeling for Learning

5.1.1 Do VR modeling tools cut down on the necessary time to acquire procedural knowledge?

VR modeling tools are easier to pick up and use for individuals not already familiar with 3D modeling. By the nature of VR modeling software being relatively new compared to conventional modeling tools which have been continually developed for decades, VR modeling tools have fewer options for students to learn to create a model. While these may be limitations for students with prior knowledge of 3D modeling have a background knowledge of complicated procedural techniques, new students to 3D modeling will be unaware of those complicated techniques and can create objects without a large amount of background knowledge.

5.1.2 Does VR modeling improve learning of strategic knowledge?

VR modeling allows for the rapid creation of imprecise models, which means that many iterations can be created and reviewed in the same time it would take conventional tools to create one model. This can prove beneficial for expression-centric modeling, where multiple iterations of an idea are expected to create the final model used in the project. However, strategic knowledge in the design school relies on accurate planning of requirements and implementation of those requirements in the model. Inside the HMD VR environment, while tools allow users to import reference materials prior to beginning their modeling session, providing exact measurements through typed UIs can be difficult and break the flow of the modeling experience. Success of strategic knowledge acquisition depends on the type of strategic knowledge needed for the particular school of modeling.

5.2 Efficacy of VR Modeling

5.2.1 Do VR modeling tools provide comparable speed to conventional modeling tools?

Speed of modeling is an important factor for learning, because completing projects enables students to receive feedback on their work. While not a direct study of 3D modeling, a study of implementation of common animation tasks in VR revealed that tasks related to animation were performed faster by both experienced animators and individuals new to animation (Lamberti et. al, 2020). Freehand drawing tools in VR can offer varying degrees of speed and accuracy, depending on the type of drawing used (Dudley et al., 2018). It will be up to educators to determine which tools provide the right combination of speed and accuracy to enable students to deliver outputs for their intended purposes.

5.2.2 Do VR modeling tools provide comparable control and accuracy to conventional modeling tools?

VR modeling tools can provide freedom and ease of learning compared with conventional tools, but the limitations of current VR software mean that users need to adapt their workflow to the software tool and may not be able to use the full functionality of conventional tools they are accustomed to. When students are given free instruction to build an object without exact specifications, they can create objects in the 3D space by using the tools provided and believe the system to be usable (Huang & Lee, 2019). However, when users are asked to build something specific based on a reference using a VR tool, they may choose different approaches and end with more differing results than they would with conventional tools (Jackson & Keefe, 2016).

While VR inputs can be more precise for some tasks, the lack of specific controls and functionality can prove detrimental for individuals used to the precision afforded by mouse and keyboard setups. While desktop VR setups used before the HMD wave of VR allowed users to use their keyboard commands along with a VR view, HMD setups with controllers limit the number of direct inputs provided to users. Instead, new UIs need to be created inside the VR modeling software to provide for the functionality needed.

5.3 Summary

VR modeling tools are easy for both users new to 3D modeling and experienced 3D modelers. However, most research experiments on VR 3D modeling involves short-term use for very specific projects, and cannot provide information on the effectiveness of VR modeling for more long term use. There have been some instances of individuals using VR modeling tools for longer projects, such as a 2-week game jam with Google Blocks, Tiltbrush, and the Unreal Engine (Perez, 2017), Oculus Medium as a prototyping tool in coordination with other modeling tools to create a game (Hurd, 2019), or using Oculus Medium an initial drafting tool for a larger scale game (Hayden, 2018). However, individual learning experiences of developers may not transfer to learning inside of a classroom environment.

6. Recommendations for Further Research

Relatively more academic research has been performed on the design school of modeling rather than the expressive school. However, because of the tradeoffs that are made in VR tools with increased speed for reduced detail of control, research in the expressive school of 3D modeling may provide better benefits for VR modeling tools applied to expressive purposes. With that in mind, two types of studies are proposed for further research areas.

6.1 Efficacy study of VR modeling for strategic knowledge acquisition in a college-level 3D modeling art course

While research has been performed comparing the procedural and strategic knowledge instruction capabilities of instructors in design classes, instruction in the expressive school tends to expose less specific strategic knowledge in favor of letting students discover creative solutions to problems on their own. If VR modeling tools can be proven to be a better way to instruct students to create more effective 3D modeling, a framework of strategic knowledge for expressive school 3D modeling instruction needs to be created. After this framework is created, a direct comparison can be made by incorporating strategic knowledge instruction into the procedural knowledge instruction for both conventional and VR modeling tools. Through some of the methods described above for measuring strategic knowledge retention, conclusions can bee drawn on whether VR modeling provides instructional benefits when incorporated into a 3D modeling classroom.

6.2 Pilot study for VR 3D modeling within the game development pipeline

To better explore 3D modeling in the context of game development, VR 3D modeling tools can be provided to groups of students working on game projects as part of a capstone project. Each student group could be provided with different 3D modeling pipelines. Firstly, one group would be provided with conventional modeling tools only to create assets to be incorporated into a 3D game. A second team would be provided with VR tools and expected to use VR tools without conventional modeling tools. Lastly, a third team would be provided with VR modeling tools but would be expected to perform standard clean-up tasks in conventional modeling tools. A process of interviews with the teams over the course of their project development would provide insights into the applicability of VR modeling tools for the game art

asset pipeline and what types of features would be needed to improve VR modeling tools' capabilities.

7. Conclusions

VR 3D modeling tools are a long way from displacing conventional modeling tools in the 3D modeling classroom, but they may have a place in the classroom when barriers to their implementation are removed. There are still many barriers to implementation of VR modeling tools, such as the cost of hardware, the necessity of adequate physical space to use VR modeling tools, the development of training and education materials comparable to conventional modeling tools, and ensuring knowledge transfer of VR modeling into contexts applicable to prepare students for future industry or academic work. In addition, the current trend of HMD VR is not guaranteed to last forever, and other styles of VR tools may prove to be more effective for 3D modeling education even if they do not yet have commercially available platforms. More research is needed into effective practices with these tools.

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