

Virtual Reality in Academic Health Sciences Libraries: A Primer



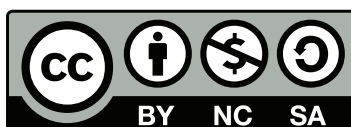
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Table of Contents

Preface	4
UW Health Sciences Library: Using virtual reality to support health care	6
Project team	8
Definitions	9
VR room requirements	11
VR play area	14
Audience area	16
Room lighting	19
VR gear storage	21
VR hardware and software options	23
VR headset options	26
VR computer requirements	30
Software	31
VR audience support	35
Group seating options	26
Solo seating options	30
Display	31
Writable surfaces	42
References	43

Preface

This primer, an investigation of virtual reality (VR) in academic health sciences libraries, offered an extraordinary opportunity to meet and talk with University of Washington (UW) researchers, residents, and clinicians about the future role of research libraries. What I found most energizing was the ability to view our library spaces and profession in new ways based on those contacts and conversations.

Intended audience

Libraries come in all shapes and sizes, but they all seek to make the most use of their spaces and deliver relevant programs to a broad array of users. My professional involvement in the American Library Association has made me see the need to identify and test new ideas in space and services now in order to prepare research libraries for the future. Modern health sciences libraries are faced with many essential challenges—optimizing data management, ensuring equitable access to information, providing resources on personalized medicine, and constructing an information pipeline for future biomedical researchers—that are requiring us to rethink our future space needs together.

Academic health sciences libraries deliver high-quality experiences, using the latest technology and furnishings, to users seeking to improve health and health care delivery. All of our services are tested and informed by faculty, staff, and students to ensure that they are both functional and appropriate. UW's addition of a virtual reality component to a new Translational Research and Information Lab (TRAIL) in 2018 is providing prompt advice to library directors and IT leaders.

How this primer should be used

Treat this *how to* manual as a primer, a case study, and a reference on the preferred hardware and software, lighting, and interior design elements to consider in your VR planning process. This primer will help you:

1. introduce VR to your current library space
2. gain insight into VR hardware and software for higher education and health care
3. increase productivity and collaboration by using a data wall for VR demonstrations to small health care teams

Planning for potential uses of VR

The University of Washington Health Sciences Library's (HSL) transformation of its library liaison office into the TRAIL collaboration space for use by thousands of health sciences researchers was an exciting challenge for our team. The idea was to combine a translational research lab with a library possessing a strong clinical information program and IT services. We incorporated a collaborative layout that allowed for small, focused discussions using a data wall and emerging technologies.

The need for a VR space for clinical researchers was highlighted by the results of a UW Libraries survey, stakeholder conversations within the six local UW health sciences schools, the UW Center for Cardiovascular Innovation, and a student advisory group. As part of this process, I learned that if the health sciences library were to remain relevant to researchers in 2030, the planning and testing of space and design concepts needed to begin immediately.

When the library decided to create a space for researchers—especially clinical researchers involved with patient care—we learned that our potential users wanted a completely new kind of experience that involved the latest technology and embraced the guiding principles of equitable access to high-quality health information and data.

The Institute of Museum and Library Services (IMLS) provided funding through a Library Leadership Grant to inform this primer and create a document that would encourage libraries to offer new services and VR spaces.

The experience can serve as a model for others to make the most of their library space options and persuade colleagues of the benefits of including library leaders in any future plans for innovation spaces, technology labs, and programs for improving community health.

Acknowledgements

Adam Garrett and Dmitry Levin stepped forward to offer leadership and advice during the one-year VR project.

Diversified designed the data wall.

Ed Verrier, MD, Beth Ripley, MD, Mark Reisman, MD, Kevin Koomalsingh, MD, and Francisco Gensini, MD, demonstrated the value of partnerships.

IMLS funded the work because there was a demonstrated need in the library community. A special thank you to my AAHSL colleagues at the Arkansas College of Osteopathic Medicine, Howard University, Jefferson College of Health Sciences, McGill University, Northwestern University, Southern Illinois University, UCSF, University of Minnesota, University of Oklahoma, University of Pennsylvania, University of Rochester, University of Toronto, Virginia Commonwealth University, and Weill Cornell Medicine for their support.

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UW Health Sciences Library: Using virtual reality to support health care

The Translational Research and Information Lab (TRAIL) opened in the University of Washington Health Sciences Library (HSL) in December 2016, transforming existing library space into an innovative and data-driven research environment. Clinical researchers are using it to accelerate innovation in health care using translational methods and the latest technology.

The innovation space has six 55-inch digital panels that form a data wall. Semicircular “campfire”-style seating and sound-dampening floors allow for focused discussions. The vision is to provide a collaborative space where researchers and clinicians can meet to develop ideas, test concepts, and explore possibilities.

A research scientist from the UW Center for Cardiovascular Innovation contacted the TRAIL librarian for permission to test VR on the data wall. Through this successful interaction, a case

was made for VR to be used in HSL. A data wall displaying a patient heart, for example, can show a team of health care providers what a cardiovascular surgeon will see in the operating room.

For decades, surgeons relied on two-dimensional MRI and CT representations of the heart they would be operating on hours later. This project added a third dimension—depth—by transferring those MRI and CT slices into a detailed, immersive, and patient-specific VR model. The VR models then serve as a foundation for pre-surgical consultations, allowing the surgical team to explore the patient’s anatomy collaboratively, and letting UW health care providers and librarians to reimagine the future of case conference presentations.

Soon, a partnership came about to assess how sophisticated VR techniques could revolutionize pre-surgical cardiovascular consultations and inspire other libraries to design high-tech spaces.



Above: Initial artist rendering for implementing VR into UW HSL's TRAIL.

Below: Seated (from left): Adam Garrett; Emily Patridge, MLIS; Gili Meerovitch; Tania Bardyn, MLIS; Beth Ripley, MD; Dmitry Levin; Ryan James; Edward Verrier, MD. Standing (from left): Mary Kay Voss; Deric Ruhl; Michael Moore, MIST; Chris Burke, MD; Francisco Gensini, MD; Kevin Koomalsingh, MD; Mark Reisman, MD; Nicole Walker, RN; Aaron Daub, MD; Margrethe Søvik, Kara McDonald, Sandeep Napa, Hendeke Araya. (Photo by Jane Koh)



Project Team

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Definitions

Case conference: A formal and structured meeting between the interdisciplinary members of the pre-surgical, surgical, and post-surgical teams to coordinate upcoming procedures. Case conferences can identify or clarify a patient's status and issues, review and strategize surgical planning, and map roles and responsibilities.

Center for Cardiovascular Innovation (CCVI): An integrated platform consisting of experts in cardiology, cardiac surgery, cardiac anesthesiology, radiology, and engineering, who collaborate in the development, translation, and clinical implementation of diagnostic and therapeutic devices to reduce the burden of suffering from cardiovascular disease.

Computed Tomography Scan (CT scan): A cross-sectional imaging technique most commonly produced using x-rays and a computer. CT scans can be used with MRIs to create three-dimensional VR models.

Data wall: A multi-screen, ultra-high-definition digital display to support presentations and visualizations. Pictured on p. 10.

Driver: The user wearing the VR headset and guiding the VR experience. **See p. 18.**

Magnetic Resonance Imaging (MRI): Detailed anatomical imaging technique produced using magnetic fields and radio waves and a computer. MRIs can be used with CT scans to create three-dimensional VR models.

Play area: The real world area in which the VR user can walk around, with movements replicated within the virtual environment. **See p. 14 for more information about the play area.**

Translation Research and Information Lab (TRAIL): A five-partner initiative accelerating innovation in health care through tools, team science and applications at the University of Washington. The Health Sciences Library is a partner. Pictured on p. 7 (top).

Virtual Reality (VR): An immersive and interactive computer-generated experience that transports the user into an entirely virtual 360-degree and three-dimensional environment, most commonly generated by a VR headset with a head-mounted display. Users look, move, and interact with the environment using handheld controllers.

VR headset: A head-mounted display that immerses the wearer into a 360-degree, three-dimensional virtual environment. The headset simulates the virtual environment by completely covering the wearer's eyes with two high-definition screens and tracking movement through space via accompanying sensors or onboard cameras. Also referred to as "VR goggles." **See p. 26 for headset options.**

VR sensors: Used to track the VR user's location within the play area by monitoring the movement of the headset and controllers through space. Sensor types vary by headset; the HTC Vive uses the laser-based, inside-out Lighthouse system with sensors placed at near-ceiling height corners of the play area, while the Oculus Rift uses an optical-based, outside-in tracking Constellation tracking system with infrared sensors at desk level and only feet apart.



Dmitry Levin (standing, from left), Ryan James, and Beth Ripley, MD, give a presentation on the potential of VR in health care

(Photo by Molly Duttry)

VR room requirements

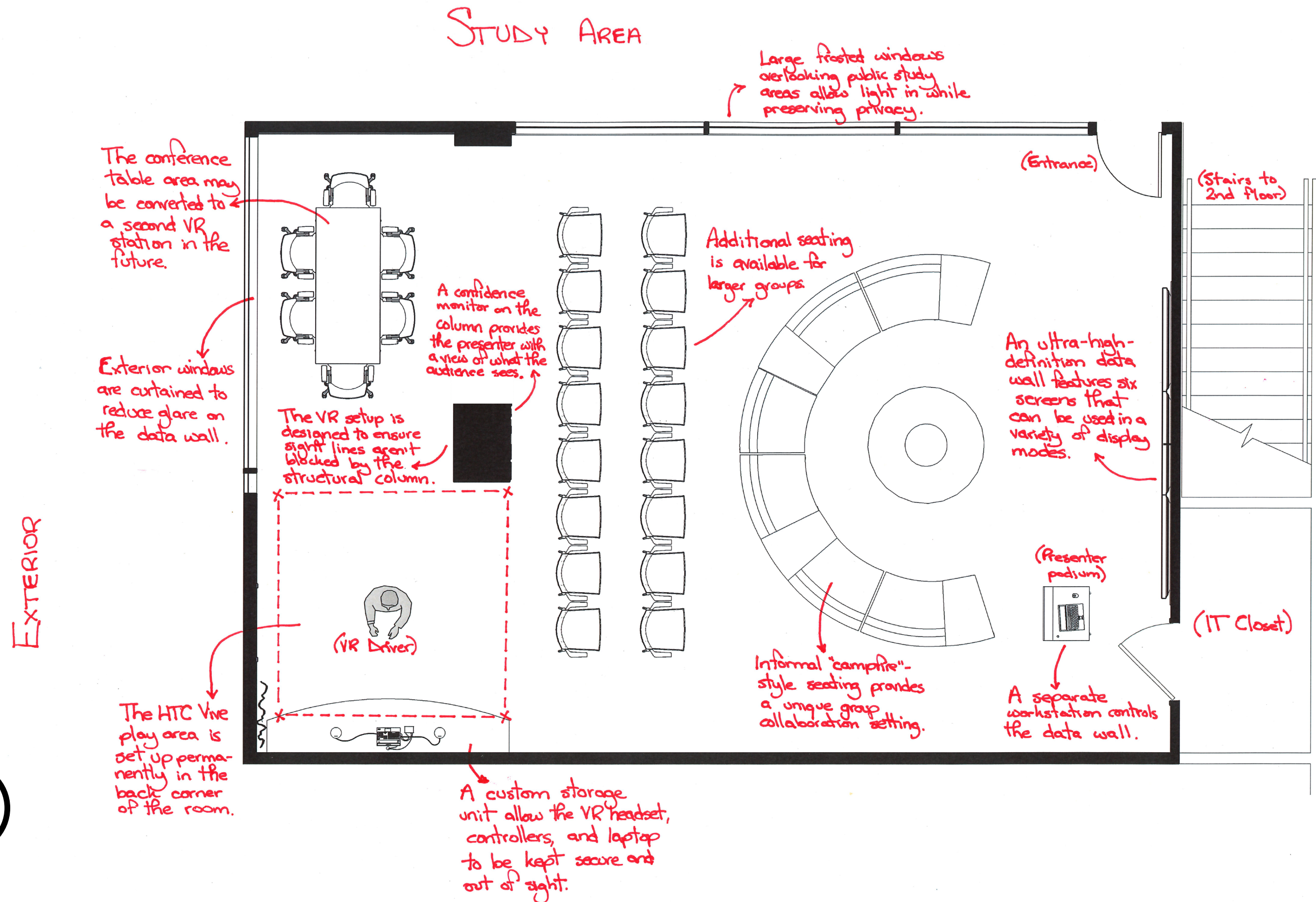
From small single-person setups to large audience-driven arrangements, finding the ideal space for a virtual reality studio is essential for its long-term viability. Space is always at a premium in modern libraries, but the latest VR gear has made the setup more feasible than ever before. One-person VR setups can be housed in a spatially-economic location the size of an academic library group-study room, while larger areas can be retrofitted to support VR as an add-on to other activities.

With the help of an experienced library design architect, the University of Washington Health Sciences Library developed best practices for optimizing and renovating a space to accommodate a VR setup for any project goal. This section will explore a variety of questions that planners must consider when establishing a suitable space, both for solo VR users and for larger, audience-focused applications. Topics and questions include:

- **Room size** How much floor space is needed for a VR play area?
- **Audience support** What must be considered for hosting audience-driven VR viewing activities?
- **Lighting** How is VR impacted by natural and artificial light?
- **Flooring** How can floor surfaces be improved for improve user safety?
- **Infrastructure** What is needed behind the walls to support a VR setup?
- **Privacy** How can libraries protect patient privacy?



Transforming TRAIL: Adding VR to an existing library space



VR technology has evolved and, it is now feasible for academic institutions to dedicate precious floor space to their own VR studios. Modern VR setups no longer require large swaths of dedicated floor space; they can now be packed up and stored elsewhere then brought out and quickly set up when needed. Floor space can be used for other purposes throughout the day.

Before establishing a VR space, however, carefully consider the project's intended goals, and how they align with the larger aims of the health sciences library. These project goals—whether simple solo exploration of available apps, group instructional offerings, or complex pre-surgical case planning—will largely shape the requirements of the VR studio and the features necessary to ensure long-term viability.

Consider two key questions when deciding whether a room is suitably sized for a VR setup:

- Is the room adequate for the person inside the VR environment?
- Is the room suitable for the audience watching the VR experience?

VR Play Area

Finding sufficient room for the VR play area is a straightforward problem—ultimately, the play area is just a big empty space. Though VR can be set up for a single user in a stationary standing or sitting position, in order to harness its immersive benefits users must freely walk around the virtual environment and explore it from a full 360 degrees—referred to as “room scale” in VR parlance.

Consider these five elements when choosing the location for the VR play area:

1.FLOOR SPACE: The minimum and maximum room-scale specifications vary from headset to headset—see p. 26-29 for more details—but at most, the rectangular-shaped play area won't exceed 5 meters on the diagonal. Creating a play area larger than that can lead to tracking issues between the headset and sensors.

2.BUFFER ZONE: An additional buffer of at least 1/3 meter should be left between the virtual boundaries and the physical walls of the room to avoid users walking into the wall or hit it with a controller. It is better to have a

smaller play area with an adequate buffer than trying to max out the play area.

3. OBSTRUCTIONS: The floor space must be unobstructed to prevent users from running into shin-height obstacles while they maneuver blindly through the VR environment. Ensure the zone above the play area (up to 2.5 meters above the floor surface) is free and clear of suspended light fixtures, speakers, signage, and other elements. VR users won't be able to see them, and they can become dangerous targets when users (particularly tall ones) reach above their heads.

4. COMPUTER: Most VR headsets are powered by a gaming computer or laptop. This should be kept outside the play area to prevent any accidents, but close enough to allow for sufficient slack in the cables. Both the Oculus Rift and HTC Vive connect to the computer via HDMI and USB cables.

5. FLOORING: One of the major selling points of VR is its immersiveness; virtual environments can feel real. Unfortunately, some users' minds and bodies struggle to marry what is being (con't on p. 16)



VR as a Layer: Saving library space by building VR into an existing room

Library space has never been as needed—or as scarce—as it is today. Finding and devoting a suitable unused or under-utilized space solely for a new VR project may not be feasible for many academic libraries, especially if it is meant to host large groups.

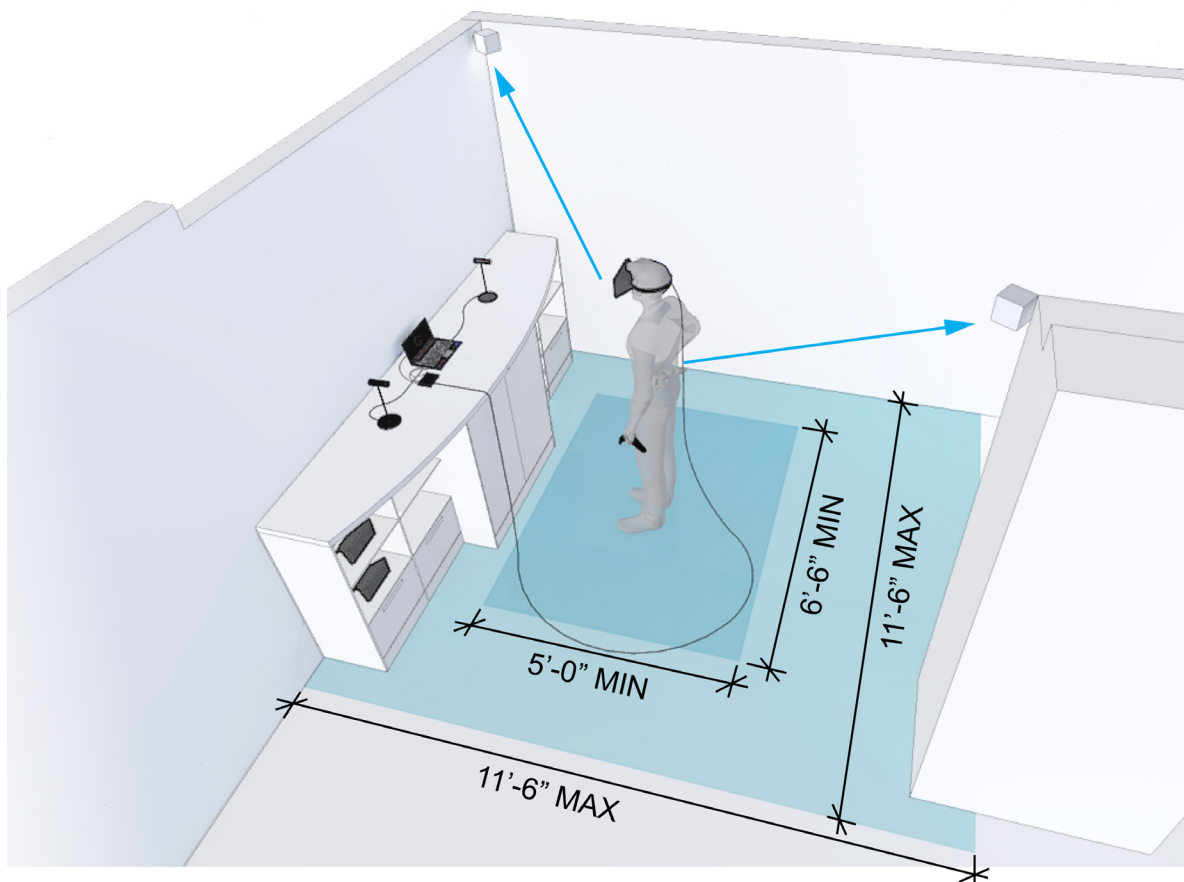
However, VR does not necessarily need its own dedicated space. Instead, consider VR as an additional service layer in an existing space.

The UW HSL TRAIL space was envisioned, designed, renovated, and launched well before any plans for incorporating VR were devised. Simply augmenting that existing space with VR eliminated the headache of finding and retrofitting another room. The VR gear can be packed away and the sensors left attached to the walls when the room is used for other purposes. This setup helped improve a function of TRAIL that health sciences researchers and clinicians were already familiar with and fond of.

seen in the headset with the reality outside of it, causing them to experience dizziness, vertigo, and nausea. Resilient floor covering, such as rubber, linoleum, or luxury vinyl tile (LVT) is appropriate for its durability, low price point, simple upkeep, and availability in a wide range of colors, patterns, and textures. Flooring with varied textures can help users situate themselves in the real-life room. For room-scale VR environments, area rugs or anti-fatigue mats covering the play area can alert the user when they are physically close to the boundary, similar to the warning track in a baseball field.

Audience Area

Finding floor space to support individual exploration inside VR is relatively straightforward. But allocating space to accommodate people inside the room but outside the VR environment is trickier and depends on what the library wants to accomplish with the setup. Supporting an audience raises a slew of new questions that must be considered both when choosing a suitable room and setting up its various features. The play area in TRAIL ultimately only takes up a fraction of the room's total space.



A rendering of the HTC Vive “play area” in the UW HSL TRAIL space. VR’s room scale component uses wall-mounted sensors to track a user’s physical movement in the real world and have those motions replicated in the virtual environment. For medical VR applications, the user can physically walk around and even through an anatomical model rendering, immersively viewing it from a complete 360 degrees. When in the VR environment, the user will see a virtual “fence” to warn against walking into a real-life wall or column.

(Rendering courtesy of Pfeiffer Partners Architects)

Each library exploring VR will have different project goals, and each room will have its own set of idiosyncrasies and design quirks, making it difficult to provide a comprehensive list of criteria that will apply in all cases. Instead, this primer will discuss how the UW HSL has redesigned the TRAIL space to accommodate VR and explain the thinking behind each decision.

The TRAIL play area ultimately took up only a fraction of the total room's total space.

The UW HSL VR project was designed to host pre-surgical consultations for large clinical teams examining patient-specific three-dimensional models on the room's data wall—a six-screen, ultra-high-definition display used to support data visualizations and presentations. Floor space for other group-focused setups—for example, an education-centric project using VR to teach anatomy to medical students—must be carefully planned based on the expected number of onlookers.

To support case presentations, the room space had to accommodate three groups: the driver, the presenter, and the audience.



Room Infrastructure: Providing the power and internet required for VR

Virtual reality technology is designed to work in consumers' homes without requiring any major overhauls—just plenty of electrical and data outlets and an internet connection.

- **Power.** Most VR hardware, including laptops and sensors, can plug into standard 120V outlets, though some setups require more sockets than others. The HTC Vive, for examples, requires four: one each for the two sensors, one for the headset, and one for the laptop. This could either restrict the play area's location or require some extension cords.
- **Network.** Like most software, VR relies heavily on online and cloud-based platforms. Users need to log into online, DRM-protected system like Valve's Steam software platform to download and run programs. Many medical VR applications also connect to sizable online anatomical models that require significant bandwidth. An ethernet connection for the laptop is ideal.
- **Computer.** A separate and dedicated rack for controlling the room's video display or data wall (see p. 40), if available, is also recommended and is part of of TRAIL setup.



Physical Privacy: Securing the VR studio when viewing patient data

Medical imagery requires an increased need to preserve privacy and discretion, regardless of whether they images are in two dimensions or three, displayed on a computer screen or hovering in VR. Libraries planning VR offerings that focus on patient-specific learning and planning must be particularly sensitive to ways in which the physical elements of a room support patient confidentiality.

The VR models can be stripped of all patient identifiers, but it is still best to err on the side of caution to prevent passersby inadvertently seeing them as they walk by doors and windows. Thick, opaque curtains not only block out the light, but exclude peering eyes as well. Window frosting has a similar effect, though it is less efficient in keeping out the light. Any doors linking the public area to the VR play area should be kept closed at all times when sensitive images are displayed in VR.

This primer will go into more detail about digital privacy concerns of VR equipment on p. 25.

1. DRIVER: The individual (an imaging specialist from the surgical team) wearing the VR headset who serves as the navigator within the virtual environment, moving through the model as requested by the presenter.

2. PRESENTER: The lead for the case presentation, who explains the patient model and upcoming procedure to the assembled surgical team and verbally guides the driver through the virtual model.

3. AUDIENCE: A group of 15-20 surgeons, nurses, radiologists, and other members of the surgical team attending the case presentation and watching the VR model displayed on the data wall. The audience can also call out instruction to the operator from time to time, modeling team health care and encouraging a multi-disciplinary approach.

The project goal established the context to help shape design considerations. To maximize the available TRAIL space, layout options and room orientation were examined for best use and optimized outcomes. Three elements were considered:

1. SIGHT LINES: To hold effective case presentations, the audience must be able to see the VR imagery clearly. One of TRAIL's significant challenges is a structural column that blocks vision for a sizable section of the room.

2. VR PLACEMENT: In addition to the requirements mentioned earlier, the play area should ideally be set off to one side to avoid blocking the screen yet close enough for the driver to comfortably receive instructions and take part in the conversation.

3. PRESENTATION SPACE: The case presenter needs to be in view of the audience to guide the conversation, remain close enough to the driver to direct the VR experience, and access the controls for the display.

TRAIL's original orientation placed the data wall on the west wall and the VR play area in the southwest corner. In that setup, the structural column essentially blocked any sight lines in the northern-most fifth of the room, and presented less than ideal viewing angles in other parts.

After exploring options and considering the associated costs, UW HSL is planning to flip the room orientation 90 degrees to better support the VR project. Relocating the data wall to the south end of the room will open new possibilities and help turn a challenge into an opportunity. In this configuration, the audience sight lines will no longer be compromised, and the structural column will become a useful feature. In the new setup, the south side of the room will be dedicated to audience and presenter while the rear of the room (north of the existing column) will house the VR play area(s).

Room Lighting

As with room size, VR planners must consider two major outcomes when considering the lighting to support a VR studio: impact on the VR user and impact on the audience.

IMPACT ON VR USER

Thankfully, the immersive nature of most VR headsets means real-world light has little effect on the individual in the VR environment. The headsets use infrared light for the tracking system to establish the user's location, and work best in low- to medium-light environments. Normal lighting works fine, as long as it isn't oppressively bright and shining directly onto the sensors. While total darkness would not impact the sensors, at least low light is required to ensure that the user doesn't bump into objects after taking off the headset. VR is by its very nature disorienting, and the user might need a few moments of reorientation after returning to the real world.

Ideal VR environments are free from the reflections caused by glass, mirrors, and other polished surfaces. Those elements hinder more than just visibility; reflective surfaces (even a particularly shiny whiteboard) can prevent the VR sensors from tracking movements properly. Finish materials should be neutral in color such

Ideal VR environments are free from the reflections caused by glass, mirrors, and other polished surfaces.

as off-white or light cool gray wall paint. If additional acoustical treatment is needed, full-height, wall-mounted, fabric-wrapped panels can provide a good solution. These are available in a wide range of hues, the best being solid, pattern-free colors matching the wall paint.

IMPACT ON VR AUDIENCE

Tweaking the lighting to support an audience watching VR imagery displayed on a laptop, television, or data wall requires more thought and planning. This is particularly true for complex medical imagery. The audience's ability to see



Thick curtains over internal and external windows create a VR space suitable for collaborative, large-group viewing.

(Rendering courtesy of Pfeiffer Partners Architects)

precise details is crucial, and a glare-filled room can make it hard to discern whatever is on screen.

One of the more challenging elements in setting up the VR equipment in TRAIL was handling the room's ambient light, even in a city as perpetually gray as Seattle. TRAIL's northern wall features a window looking out onto a busy campus thoroughfare that leads to the main entrance of the UW Medical Center. The north-facing window might not be a concern for direct sunlight, but it lets reflections from moving vehicles into the room. Under certain conditions, these dynamic reflections are visible on the video screens.

To counteract that ambient light, opaque or room-darkening solutions are suitable. Window treatments using drapery, solar shades, or blinds offer varying degrees of light transmission. For drapery, select a fabric with either solid or small-textured design in a neutral color, as large patterns and bright colors. An additional stain or soil resistant treatment is recommended. For a solar shade, select a fabric with a tight weave (3% openness). If the VR room has a large southern or eastern exposure, consider a window covering that can both mitigate glare and reduce radiant heat.

VR Gear Storage

VR headsets and laptops are both expensive and relatively lightweight, making them alluring targets for unscrupulous passersby. Libraries must balance securing their costly gear with ensuring the VR experience isn't hampered. HSL's basic setup naturally lends itself well to increased security: TRAIL remains locked when not in use, and users must book an appointment in the VR studio through an online form. A librarian or other staff member is responsible for opening the room for them.

This setup isn't feasible for all libraries, especially those desiring to offer a continually running service where students and researchers frequently enter and leave the studio. Having a library employee—even a student worker—on hand serves as a powerful deterrent. Key card or coded-lock access can also ensure only trusted individuals are allowed into the room.

Originally, HSL stored the VR gear (laptop, headset, controllers, wires, etc.) in an HSL employee's locked office and brought it out when requested. HSL plans to install a lockable storage unit within TRAIL specifically for VR equipment. The unit will provide an added layer of security and ensure that the gear is on hand for quick setup. TRAIL is frequently used for non-VR purposes, and stowing the VR gear out of sight preserves the functionality of the room.



Pyrus Medical's Ryan James demonstrates his company's Bosc software using an Oculus Rift headset

(Photo by Molly Duttry)

VR hardware and software options

Virtual reality has officially gone mainstream. Technology that was previously reserved for organizations with tens of thousands of dollars to spend on dedicated VR studios, is now marketed to consumers. VR headsets now cost as little as a few hundred dollars and are designed for use in people's homes.

This mass market appeal has brought with it increased interest from hardware and software developers. From industry leaders like the HTC Vive and Oculus Rift, to more recently released options like Microsoft's line of Windows Mixed Reality headsets, consumers now have a handful of hardware options for their VR setups.

As part of its VR project, the University of Washington Health Sciences Library explored and tested many of the options currently available for a medical VR setup. This section looks at hardware and software required to start a VR studio, based on the HSL staff's experience. Topics and questions include:

- **Headsets** Which headset best meets the needs of a library's specific VR project?
- **Computer** How much horsepower is needed to drive a VR headset?
- **Software** What medical software is available?
- **Second setup** How can installing a second VR setup in the same space improve efficiency?
- **Digital Privacy** Can VR keep patient data secure?



Second VR Headset Setup: Improving case presentation efficiency

Consider adding a second VR station for case conference presentations. Depending on the software, this can allow two users to take part in the same VR environment. For medical case presentations, this allows for quick switching between patient models. A new setup can be ready to launch as soon as the first one concludes, minimizing wasted downtime.

The HTC Vive can even use the same Lighthouse sensors to track multiple VR headsets within the same play area, with a pair of caveats. First, keep in mind that this will probably require a separate computer for heavy-duty applications; even high-powered gaming laptops are sometimes stretched to their limits supporting one VR headset—adding a second will have a serious negative impact on performance. Second, VR users are effectively blind when wearing the headsets, and would need a chaperone to prevent them from walking into each other.

Current VR technology has advanced significantly since the early days of VR, with cumbersome headsets and clunky controllers usually housed in a futuristic-looking dedicated VR lab. Today's gear is far sleeker, lightweight, portable, and designed to be used in people's homes.

Technology heavyweights like Microsoft, Facebook, Google, and HTC have developed new and better gear. Increased marketplace competition has driven down prices and made VR more accessible than ever, and software developers are increasingly bringing their new offerings to VR platforms.

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For health sciences libraries, VR offers an innovative realm for clinical and educational services that is economically and logistically feasible.

Three main components constitute VR technology: the headset that creates a virtual world, the computer that powers it, and the software that guides the user through it.

1. VR HEADSET: The VR headset is the gateway between the physical and the virtual worlds. It uses twin high-definition screens and tracking sensors to simulate immersive VR environments. Though the current generation of VR gear is still dominated by the Oculus Rift and HTC Vive, new and advanced options are emerging each year.

2. COMPUTER: Immersive and interactive VR environments require significant graphical and computational horsepower. VR tricks the mind into accepting the virtual world as real, but insufficient power can cause stuttering and create a disconnect between the real and the virtual.

3. SOFTWARE: Once the headset is up and running, software programs are added to support the intended service offerings. VR's software market is dominated by video games, but educational programs are creating a niche. Health sciences VR programs fall into two broad categories: anatomical education using generic models and clinical case preparation using patient-specific renderings.



Digital Privacy for Libraries: Understanding VR data concerns

Today, it is virtually impossible to avoid sharing personal data and creating a virtual footprint. Websites, computer programs, and smartphone apps are constantly recording user data. VR is no exception; user actions are tracked through cookies, aggregated data, and IP-based information.

This data is often used to market services to the user, and shared beyond the headset manufacturer. Oculus, for example, declares in its privacy policy that it can “share information within the family of related companies that are legally part of the same group of companies that Oculus is part of,” which includes Facebook, itself no stranger to high-profile data privacy concerns. Data is often transferred across international borders, and stored in other countries.

Data sharing is by no means restricted to VR, but users should be aware of what takes place when they put on their headsets. This is particularly important with potentially sensitive material, such as identifiable patient information or models.

VR Headset Options

Although the number of available headsets is increasing, the market is still largely dominated by two giants: the HTC Vive and the Oculus Rift.

HTC Vive



Developers: HTC (New Taipei City, Taiwan) and Valve Corporation (Bellevue, Washington)

Launched in 2016, the HTC Vive allows users to move around the room-scale environment. It has an “inside-out” tracking system with embedded sensors that pick up external signals from two base stations installed at opposite corners of the play area to track the user’s location. The base stations plug into standard outlets, and communicate with the headset via Bluetooth, making the system easily adaptable to rooms of all sizes. Base stations can either be installed permanently (mounted on a wall or rail) or mobile (mounted on an adjustable light stand). The headsets are physically connected to a computer via USB port.

The Vive’s front-facing camera lets users view the actual room while still wearing the headset in a mode that resembles that portrayed in *The Matrix*. The Vive was slimmed down in 2017, reducing it from 555 grams to 470, on par with the Oculus Rift.

Users can connect to Valve’s market-dominating Steam software platform, providing Vive users with access to thousands of games and apps. Users can also connect to the dedicated Viveport app store.

HTC Vive (Image courtesy of HTC)

Oculus Rift



Developers: Oculus VR (Irvine, California) and Facebook (Menlo Park, California)

Oculus launched its signature product, the Rift, in 2016. The Rift excels at stationary VR by using an outside-in system with sensors (web cameras with wide-angle lenses) that track the infrared light emitted from the headset and controllers to determine the user’s position. The Rift’s typical setup consists of two sensors on opposite sides of the computer, connected by USB cables. Users are capable of 360-degree movement, allowing them to turn freely inside the play area.

To accommodate compact play areas, the two sensors can be placed between 3 and 6 feet apart. The user faces them to avoid any physical obstructions between the sensors and the controllers. Adding a third sensor to the computer via by USB cable allows for true room scale, similar to the Vive. Headsets must be physically connected to the computer via USB port. The Rift’s 470-gram headset weighs the same as the Vive, though Oculus’ controllers are more compact than their HTC counterparts.

Rift users can also connect to Valve’s Steam software platform, as well as the dedicated Oculus store.

Oculus Rift (Image courtesy of Oculus VR)

Head-to-Head Comparison



VS.



US\$499	COST	US\$399
2160 x 1200 pixels (1080x1200 per eye)	RESOLUTION	2160 x 1200 pixels (1080x1200 per eye)
90Hz	REFRESH RATE	90Hz
6	DOF (degrees of freedom)	6
2 in high corners of room	SENSORS	2 on desktop (optional third)
Yes	ROOM SCALE	Requires third sensor
Min.: 2m x 1.5m Max.: 5m on diagonal	PLAY AREA	Min.: 1m x 1m Max.: 2.5m x 2.5m

Alternative Headsets for Library Use

Windows Mixed Reality

Developers: Multiple

Price: Varies by model

The Rift and Vive-dominated VR market was somewhat upended in 2017 with the release of the Windows Mixed Reality (WMR) headsets. Various developers, including Acer, Dell, HP, Lenovo, and Samsung, launched their own headsets based on the same general platform. Despite the somewhat misleading name, WMR headsets are the same as other VR headsets: immersive goggles that block the user's vision of the real world. Unlike the Rift and Vive, the WMR gear relies on headset-mounted cameras rather than external sensors for tracking. Specs and designs vary from model to model, with all of them falling into the same general price point (US\$250-\$450). The WMR headsets are compatible with software in the Microsoft store and with some but not all of the offerings in Valve's Steam platform.

Pros:

- Room scale
- No external sensors

Cons:

- Quality varies between developers
- Many software programs aren't supported yet



*Acer Windows Mixed Reality Headset
(Image courtesy of Acer)*

Oculus Go

Developers: Oculus VR (Irvine, California) and Facebook (Menlo Park, California)

Price: US\$199 for 32GB, US\$249 for 64GB

Oculus took a massive leap forward in 2018 with its release of the Oculus Go, a self-contained and self-powered VR headset with no external sensors and no accompanying computer. The Go connects to the user's smartphone via the Oculus app and transfers VR apps from phone to headset. The ability to move essentially untethered significantly increases portability, allowing users to take it virtually anywhere without a computer. This eliminates the largest financial barrier for VR beginners. However, that bonus comes with a significant reduction in horsepower. The Go isn't capable of creating a room-scale environment, so users are unable to walk around virtually, and it probably will not be able to process complex images like anatomical models without experiencing major slowdown. Software is also an issue, as the newly launched Go has a limited catalog so far.

Pros:

- Self-contained, doesn't require a computer
- More affordable than other headsets

Cons:

- No room scale
- Significantly lower specs than other VR headsets



*Oculus Go
(Image courtesy of Oculus VR)*

Google Cardboard

Developers: Google (Mountain View, California)

Price: US\$15

Launched in 2014, Google's aptly-named Cardboard is truly an entry-level option for VR. The contraption is essentially a cardboard box that holds a smartphone in front of the user's eyes as it runs a VR-compatible video or software program. The setup allows new users to get a first taste of VR. But simplicity has its drawbacks. The smartphone must power the VR experience with significantly less horsepower than a gaming computer. Similarly, controllers can't be used with Google Cardboard, so users are more likely to experience the equivalent of a 360-degree movie than an immersive experience. Google also released Daydream View, a more robust headset made of fabric, in 2016 (US\$99). Other smartphone-powered options are also available, such as the Samsung Gear VR (\$130).

Pros:

- Inexpensive introduction to VR
- No additional gear required

Cons:

- Made of cardboard (fragile)
- Limited processing power



Google Cardboard
(Image courtesy of Google)

Microsoft HoloLens

Developers: Microsoft (Redmond, Washington)

Price: US\$3,000, US\$5,000 for commercial use

Unlike the other headsets on this list, the Microsoft HoloLens is not virtual reality but *augmented* reality (AR). Holographic images are projected into and interacted with in the real-world environment the user is standing in. AR has been used in other smartphone apps in recent years, such as the Pokémon Go game, Snapchat face filters, and the short-lived Google Glass. To some, AR represents the wave of the future, because it allows users to bring new information into the real world instead of traveling entirely in a virtual one. Currently, though, its large price tag is hindering its widespread adoption. As a result, developers favor VR's significantly higher adoption rate, limiting the number of commercially available AR apps.

Disclaimer: The UW HSL's project focused on VR options and did not utilize a HoloLens beyond demonstrations.

Pros:

- Holograms projected into the real world
- Potentially the wave of the future for mixed reality

Cons:

- Major price tag
- Less software available than for VR



Microsoft HoloLens
(Image courtesy of Microsoft)

VR Computer Requirements

Significant processing power is mandatory for proper support of the Oculus Rift, HTC Vive, and other VR experiences. The setup must constantly generate high-definition images in a simulated 360-degree environment, placing a significant load on the attached computer's graphical capabilities. Many of the recommended high-end VR computers on the market are essentially identical to upper-echelon gaming computers.

That intense level of computing prowess comes at a cost—a gaming laptop or computer is substantially more expensive than the VR headset, controllers, and sensors—but skimping on it could have a detrimental effect on the VR experience. Inadequate hardware results in plummeting frame rates and stuttering graphics, especially as users pivot their heads, creating a disconnect between the real world and the virtual one, and leaving the user feeling disoriented and nauseous. Some applications are more intense than others; even a mid-level computer will struggle to run heavy-duty programs.

The HTC Vive and Oculus Rift have similar minimum and recommended specs. A computer that runs one well should also be able to handle the other. Prices vary based on time of year and the market, whether constructing a computer from scratch or buying a preassembled machine. Waiting for sales or deals is advisable.

MINIMUM SPECIFICATIONS

CPU: Intel Core i5-4590 / AMD FX-8350

Graphics: Nvidia GeForce GTX 1050 Ti / AMD Radeon RX 470, or equivalent

Memory: 4GB RAM (for Vive), 8GB RAM (for Rift)

Ports: one HDMI video output, plus one USB 2.0 (for Vive) / one USB 3.0 port, plus two USB 2.0 or newer ports (for Rift)

Approximate cost: US\$1,000 (for desktop), US\$1,400 (for laptop)

RECOMMENDED SPECIFICATIONS

CPU: Intel Core i5-4590 / AMD FX 8350

Graphics: Nvidia GeForce GTX 1060 / AMD Radeon RX 480, or equivalent

Memory: 4GB RAM (for Vive), 8GB RAM (for Rift)

Ports: one HDMI video output, plus one USB 2.0 (for Vive) / three USB 3.0 ports, plus one USB 2.0 or newer port (for Rift)

Approximate cost: US\$1,500 (for desktop), US\$2,000 (for laptop)

Software

Once the computer is on and the VR headset ready to go, the next choice is what software to purchase. With VR's explosion into the mainstream marketplace, it has become a major focus for developers, and hundreds of new applications are being released every day.

Though gaming remains VR's primary outlet, educational software applications are on the rise. Health sciences applications can be broken down into two areas:

1. EDUCATIONAL: Applications designed to teach medical students about anatomy and human structures.

2. CLINICAL: Applications designed to visualize patient-specific VR models to support pre-surgical conferences and case planning.

This primer will highlight four currently available software packages that UW HSL uses in its VR studio: 3D Organon VR and Anatomy Labs for educational applications, and Bosc and Medicalholodeck for clinical ones.



VR Software Licensing: Complying with programs' terms of services

With VR software still in its relative infancy, licensing models are basic. Most programs are marketed to the general public or for-profit corporations rather than academic institutions. As a result, few VR applications offer educational licenses. This poses a problem for academic libraries with limited budgets that don't wish to pay massive fees for an institutional license.

With licensing still in a gray area, library directors need to be cautious in deciding what applications to purchase and how to offer them to patrons. Many VR programs are available for relatively low one-time fees through services like Valve's Steam software platform, but these platforms are inherently designed for single-person use with digital rights management (DRM) language in the terms and conditions. In such a murky environment, purchasing a single-person license then providing it to a wide audience may land the library in hot water.

Educational

3D Organon VR

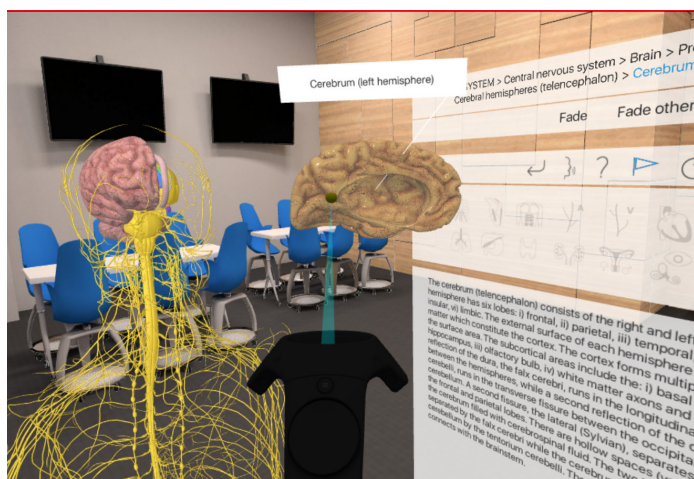
Developer: Medis Media (Surfers Paradise, Australia)

Website: 3dorganon.com

Supported headsets: Oculus Rift, HTC Vive, Windows Mixed Reality

Price: US\$30

3D Organon VR is geared towards anatomical education for medical students. In many ways it is a technologically enhanced version of traditional anatomical skeletons and models. The program, available through Valve's Steam software platform, provides over 4,000 VR models of anatomical structures in a wide array of body structures for the nervous, musculoskeletal, respiratory, endocrine, and other systems. Users can manipulate and move around each individual body part, and a separate information screen adjacent to the model provides additional information about the selected body part. 3D Organon VR offers a compelling introduction to medical VR and can be used to support teaching and learning. However, the program doesn't allow users to upload their own anatomical models into the system, limiting its use to doctors, surgeons, nurses, and other health care professionals already well-versed in anatomy.



3D Organon VR (Image courtesy of Medis Media)

Anatomy Labs

Developer: Anatomy Next (Seattle, Washington)

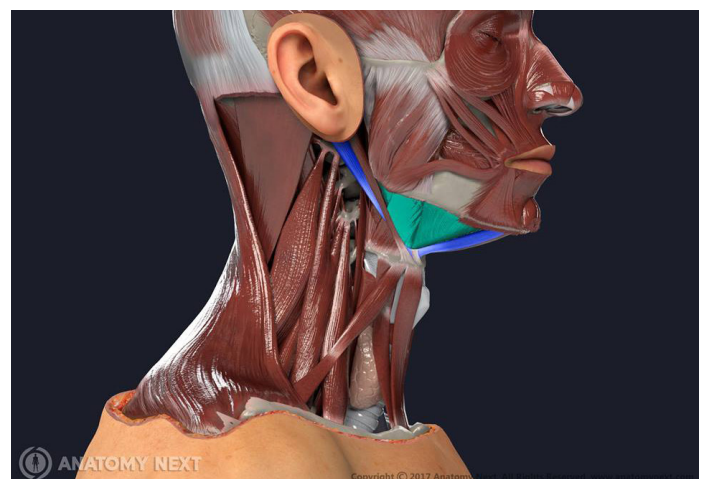
Website: anatomynext.com

Supported headsets: Windows Mixed Reality

Price: Free to download

Like 3D Organon VR, Anatomy Labs is geared towards students learning about human anatomy and anatomical structures. Developed at UW's CoMotion Labs, Anatomy Labs allows users to fully interact with a virtual cadaver, removing body parts to reveal the underlying bone, muscle, and other body structures. The program also includes built-in quizzes that test users on their abilities to accurately dissect the model. In the summer of 2018, UW HSL's TRAIL hosted to the Anatomy Next team as it partnered with the School of Dentistry in using VR as a teaching aid for students enrolled in a head-and-neck anatomy course. Anatomy Next also produces a desktop, non-VR version of the program.

As of September 2018, Anatomy Labs is only available on Windows Mixed Reality headsets.



Anatomy Labs (Image courtesy of Anatomy Next)

Clinical

Bosc

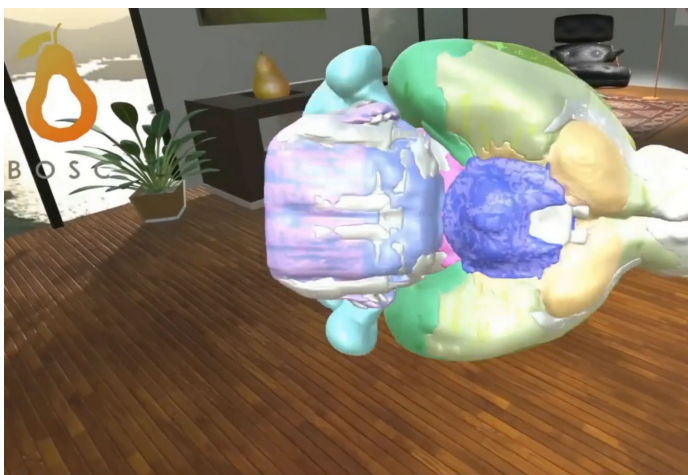
Developer: Pyrus Medical (Seattle, Washington)

Website: pyrusmedical.com

Supported headsets: Oculus Rift, HTC Vive, Google Cardboard

Price: Institutional license required

Co-founded and developed by UW PhD student Ryan James, Pyrus Medical's Bosc served as the foundation for UW HSL's first foray into VR for clinical planning. The program allows users to upload DICOM (Digital Imaging and Communications in Medicine) files generated from MRI and CT scans onto the Pyrus Medical cloud, then download and view them within the Bosc platform. Bosc's user interface includes a selection of tools for analyzing the model, including opacity and density sliders to remove body parts unrelated to the surgical plan (such as bones). A cut plane allows the user to slice into the model to take a better look inside and a drawing tool can be used to annotate the model for others in the room or for future viewings. Pyrus Medical is currently working on updating Bosc to allow multiple users to view the same model simultaneously, either in a dedicated headset or via a web-based video displayed in Google Cardboard or similar headset.



Bosc (Image courtesy of Pyrus Medical)

Medicalholodeck

Developer: Noon.io (Zürich, Switzerland)

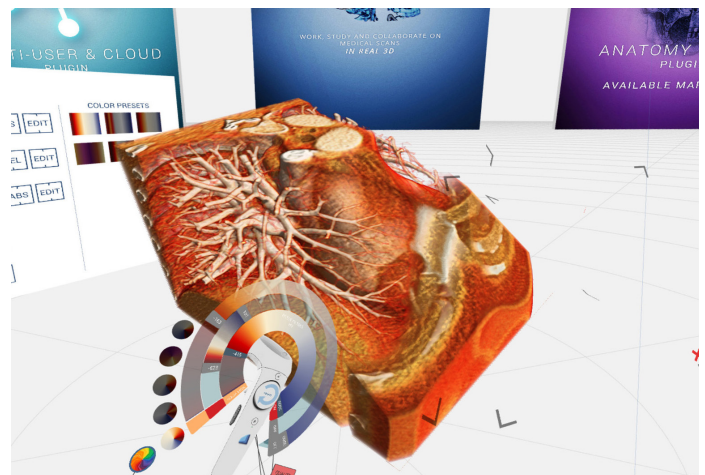
Website: medicalholodeck.com

Supported headsets: HTC Vive, Windows Mixed Reality

Price: Limited free version, US\$900 / year (Basic), US\$2,450 / year (Pro), US\$3,850 (Cloud)

This application also goes by the name DICOM Viewer for Virtual Reality (VR). Medicalholodeck offers similar functionalities as Bosc, with users able to upload DICOM files and view them as 3D models in VR. It offers a comparable set of tools, including filters for removing extraneous body parts and cut planes for sectioning away portions of the anatomy. Medicalholodeck includes a series of built-in anatomical models of various parts of the body, including a beating heart, and allows users to load multiple models simultaneously, though doing so has a negative impact on frame rate. A free version with limited functionality is available on Valve's Steam software platform.

Features included for each of Medicalholodeck's payment levels is available on the company's website.



Medicalholodeck (Image courtesy of noon.io)



Edward Verrier, MD, University of Washington (center, foreground) explains his vision for implementing virtual reality into medical curriculum (Photo by Molly Duffry)



VR audience support

With a suitable amount of floor space earmarked, a headset and computer purchased, and software installed, the VR studio is ready to launch. However, just a few small changes, such as new seating or collaboration-enhancing elements, can transform the VR experience from a solo endeavor into one that properly supports large and diverse audiences in close communication.

Working with an experienced library architect and designer, the University of Washington Health Sciences Library explored and identified options for maximizing support for audiences. Proposed changes reflect the library's VR goal of supporting large groups of surgeons, nurses, radiologists, and other clinicians as they use VR to plan cardiothoracic surgeries. Topics and questions discussed include:

- **Seating** How can various seating configurations promote collaboration and innovation?
- **Display** What display options are available for supporting collaborative viewing?
- **Hygiene** How can VR gear be kept clean and sanitary?
- **Video support** How can the VR experience be broadcast beyond the walls of the library?



Two design renderings of UW HSL's TRAIL setup to accommodate audience viewing for pre-surgical case planning.

Above: View from the presenter podium at the front of the room, adjacent to the data wall, with collaborative group seating arrangement.

Below: View from the back of the room, facing the data wall, with solo seating presentation arrangement.

(Renderings by Pfeiffer Partners Architects)



The previous sections of this primer detailed the basics of launching a VR studio in an academic health sciences library. This section focuses on taking that studio to the next level, especially for large groups. Though usually viewed as an individual experience, VR can be harnessed as a powerful tool for audiences, especially in a health sciences context with patient-specific models.

To properly support an audience, several elements must be considered in addition to the basic VR and computer technology. For a project with a specific group-focused clinical or learning goal, additional room features—such as solo and group seating, external displays, and collaboration tools like whiteboards—are essential to ensure audience members can gain as much from the experience as the individuals operating the VR headsets and controllers.

How best to modify a room to support an audience depends on the project's goals. For example, the central goal of UW HSL's VR project was to provide a viable location to host pre-surgical consultations and case planning for cardiothoracic surgery. That goal required space not for one, two, or even five users, but for groups as large as 20.

As a dedicated innovation space, TRAIL already had many of the features to support large groups, most notably an ultra-high-definition, six-screen data wall and collaborative "campfire"-style seating. Additional changes suggested through the VR project have focused on fine-tuning TRAIL's seating options to increase flexibility and create an active learning environment.



Hygiene and Cleaning: Keeping the VR studio sanitary

Headsets, resting directly on users' faces, can quickly amass an off-putting collection of dirt, sweat, oil, hair, and dead skin cells. That buildup of gunk might not be a major issue for personal, single-user headset, but it can be unhygienic if the headset is in constant use by multiple people, especially if used in or near a hospital, as many health sciences libraries are. Here are some tips for proper VR hygiene.

- **Clean and wipe.** Most VR headsets can be partially taken apart for cleaning. Fabric and cushion areas should be wiped after every use with water or wet wipes, and the lens cleaned with a dry lint-free cloth and compressed air.
- **Disposable masks.** For most major headset models, it is easy to find packs of absorbent hygienic masks online that can be swapped out between users.
- **Replace when needed.** Heavy use will likely wear out the fabric and cushion portions before the lens or inner workings, especially with regular cleaning. Those parts can be easily replaced for a fraction the headset's total cost.

Group seating options

The team-based nature of pre-surgical case planning is best served by collaborative group seating options. Often described as “campfire”-style for their half-moon shape, these large arrangements allow individuals to see everyone around them, rather than the backs of heads. An added bonus feature of some campfire seats is an attached writing bar on the backs of the seats that allows standing individuals to rest their laptops or take notes.

Suggested options include:



Steelcase media:scape Lounge

Manufacturer: Steelcase (Grand Rapids, Michigan)

Approximate price*: Varies by number of sections; and fabric; model above, without ledge: US\$9,500; with ledge: \$13,500

Website: steelcase.com

(Image courtesy of Steelcase)



Allsteel Hedge

Manufacturer: Allsteel (Muscatine, Iowa)

Approximate price*: Varies by number of sections; Triple, without base: US\$6,106; Triple, with base: US\$7,881

Website: allsteelfoffice.com

(Image courtesy of Allsteel, Inc.)

***Educational pricing may be available**

Solo seating options

Task-type stools are ideal support seats for areas behind the collaborative lounge group seating. Five-star caster bases and swiveling seats allow audience members to effortlessly adjust their position and/or turn back and forth from screen to case presenter to VR driver at the back of the room. Additional guest seating could be compact, lightweight, stackable four-leg caster-base side chairs. Space-saving chair models—with features such as folding seats and arms, or no arms—should be considered for small rooms.

Suggested options include:

HermanMiller Caper All- Purpose Stool



Manufacturer: HermanMiller
(Zeeland, Michigan)

Approximate price*: US\$800

Website: hermanmiller.com

(Image courtesy of HermanMiller)

KI Torsion Air Task Stool



Manufacturer: KI (Green Bay,
Wisconsin)

Approximate price*: US\$680

Website: ki.com

(Image courtesy of KI)

Steelcase Move



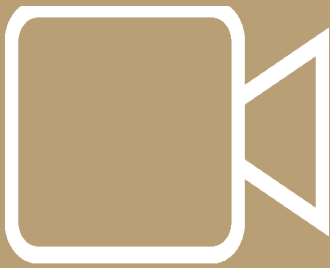
Manufacturer: Steelcase (Grand
Rapids, Michigan)

Approximate price*: US\$274

Website: steelcase.com

(Image courtesy of Steelcase)

***Educational pricing may be available**



Video Support: Sharing case presentations beyond the library walls

VR technology benefits not only students and faculty on the university's campus, but also the global community of educators seeking to learn from its capabilities. Permanent VR studios can support video capture and broadcasting, allowing many clinicians to hold routine weekly simulations with colleagues worldwide.

In developing programs that integrate into the curriculum, the VR lab's ability to capture simulated clinical sessions effectively builds a video "library" for students. Those recorded sessions, supplemented by recordings of the VR session itself, can provide an invaluable learning tool for future generations of learners.

UW HSL is investigating installing video and audio equipment to help build the foundation for that library. In particular, a 360-degree camera installed along TRAIL's western wall will allow future viewers a comprehensive look into pre-surgical planning sessions.

Display

Audience members' ability to see what is happening inside the virtual environment is crucial for case presentations. That isn't a concern for single-user activities—the user is viewing directly through the headset, and has no need for another display. Even small groups of two or three can theoretically huddle around the laptop, connected to the headset via HDMI cable. Libraries aiming to serve a wider audience, however, need to consider alternative options. Here are three display options, ranging from least to most expensive:

- 1. LAPTOP:** No additional screen, just the display on the laptop. This involves no extra cost, but provides little audience support.
- 2. TELEVISION:** A high-quality TV, similar to ones in living rooms around the world. This is an intermediate option that is solid across all categories.
- 3. DATA WALL:** An ultra-high-quality display comprised of multiple screens. This provides the best quality display, but at a major cost. UW HSL's TRAIL connects the feed to a six-screen data wall (three wide, two high).

Display Options Pros and Cons

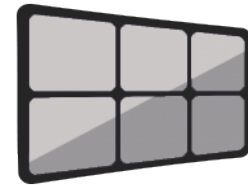
LAPTOP



TELEVISION



DATA WALL



VS.

VS.

COST



No additional costs involved.



Generally between US\$750-2,000, depending on the model.



Thousands or tens of thousands of dollars, depending on specs.

TRANSPORTABILITY



Can travel anywhere with the VR headset.



Can be placed on a cart and wheeled between locations.



Permanently affixed to the wall; requires major work to move.

AUDIENCE SUPPORT



Difficult for more than a handful of people to gather around.



Strong viewing angles that can be tweaked based on audience.



Widest viewing angles, high-quality design to limit glare.

IMAGE QUALITY



Small screen limits ability to see fine anatomical details.



Adequate for most details, might miss some finer elements.



Multiple high-definition screens can show anatomical intricacies.

Writable surfaces

Writable surfaces are invaluable for promoting collaboration and engagement. For a permanent but fixed option, cover an unoccupied wall with paint similar to Idea Paint (ideapaint.com) or apply a high-quality, non-reflective dry erase film like koroseal's Matte-rite (koroseal.com). However, individual writable surfaces or (space permitting) mobile writable easels can further enhance an active, participatory learning environment.

Here are three sample mobile whiteboards recommended by the UW HSL project architect.

Verb Whiteboard



Manufacturer: Steelcase (Grand Rapids, Michigan)

Approximate price*: US\$125 for 18 inch x 24 inch

Website: steelcase.com

(Image courtesy of Steelcase)

V-Series Mobile



Company: Egan Visual (Chicago, Illinois)

Approximate price*: Varies by size; \$950 for 36 inch x 66 inch

Website: egan.com

(Image courtesy of Egan Visual)

Thesis Mobile Marker Board



Company: Teknion (Toronto, Canada)

Approximate price*: Varies by size; US\$2,500 for 48 inch by 72 inch

Website: teknion.com

(Image courtesy of Teknion)

***Educational pricing may be available**

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