Immersive Learning: Applications of Virtual Reality for Undergraduate Education

Christie Hurrell & Jeremiah Baker
Technology, Discovery and Digital Services
Libraries and Cultural Resources
University of Calgary

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Abstract

Virtual reality technology has applications across many academic disciplines and has the potential to contribute to student centered, experiential learning opportunities. Some academic libraries have begun to offer access to this technology as part of their mission to provide broad access to information and learning resources. The virtual reality studio in the Taylor Family Digital Library, the central library at the University of Calgary, was introduced in the summer of 2016, five years after the building first opened. Since the launch of the virtual reality studio, it has experienced a diverse range of uses encompassing teaching, learning, and research across many disciplines. Due to its success, VR offerings have been expanded to include a semi-mobile VR cart, a VR development room, and loanable VR equipment. This paper will describe the configuration, access policies, and outreach activities around the library's VR services and spaces, and discuss in more detail how they have been used in undergraduate classes including kinesiology, dance, literatures, and art history.

Keywords: Virtual reality; experiential learning; undergraduate education; academic libraries

Introduction

Virtual reality can be defined as "an experience that encompasses most of the senses, including sight, hearing, and touch, and represents an alternative to reality" (Pope 2018, 5). The first robust virtual reality headset to be released on the consumer market was the Oculus Rift; it was primarily designed for the gaming market but also supports applications relating to education and exploration (Moorefield-Lang 2015). Since 2013, when the Rift was first released as a development kit, a number of other virtual reality headsets have been released, representing a variety of levels of immersion and quality. For example, the Google Cardboard uses lenses and a smartphone to give users a virtual experience, which is of lower quality and immersion, but does not require expensive hardware or a dedicated physical space. In 2016, the HTC Vive was released, and it is now one of the most popular dedicated virtual reality devices on the market, due to its sophisticated optics and its use of the already-popular game distribution service Steam. At the same time, the Vive requires a high-powered computer to avoid lags and blurriness, and is best experienced in a dedicated play space where motion-tracking sensors can be mounted (either on walls or on mobile options like tripods). Oculus, which was purchased in 2014 by Facebook, has started to release self-contained headsets such as the Oculus Go and Quest, which provide a less sophisticated immersion experience, but are cheaper and do not require any outside computer. HTC recently released the Vive Cosmos, a self-contained VR platform which competes with the latest Oculus offerings.

The literature on virtual reality often discusses augmented reality together with virtual reality under the umbrella term "extended reality" or "XR"; this article will focus specifically on virtual reality.

In recent years, the library and information science literature has begun to include more discussion of how virtual reality can be incorporated into academic library spaces and programming. Academic libraries' investment in these technologies ranges greatly, from simply providing space that other campus groups can use to deploy virtual reality equipment and related educational opportunities, to very robust programs that incorporate a teaching and research component, and are supported by specialized staff (Lee 2015; Patterson et al. 2019). The most popular virtual reality technologies deployed by libraries are the HTC Vive, the Oculus Rift, and the Google Cardboard (Pope 2018). Of the libraries with a virtual reality program that responded to a 2018 survey, over half had dedicated space within the library for a room-scale implementation, while the rest used mobile or semi-mobile options such as carts or kits, some of which can be circulated to patrons (Pope 2018).

Academic libraries have provided support and education about virtual reality by the form of credentialing programs, play-based experiences such as game development competitions, and integrations with curriculum in disciplines as diverse as art history, anthropology, biochemistry, computer science, and more (Nichols et al. 2017; Patterson et al. 2019; Lischer-Katz, Cook, and Boulden 2018; Hahn 2018). The University of Oklahoma Library, which has a very comprehensive virtual reality program, conducted student evaluations in some of these classes, demonstrating that VR assignments had a positive impact on learning (Cook and Lischer-Katz 2019; Lischer-Katz, Cook, and Boulden 2018). Some librarians have even suggested that virtual reality would be an appropriate medium for information literacy instruction (Smith 2019).

A survey of how virtual and augmented reality technologies are used in libraries, published in 2018, features responses from 101 libraries from across the world, over half of

which were academic libraries. Libraries reported that the most popular uses of virtual reality were for free play, integration with classes and workshops, special programming, and training or teambuilding. Challenges reported in the survey included the time to train and educate library users, a lack of buy in from library colleagues and/or administration, and the cost and time of maintaining equipment (Pope 2018). Other libraries have also highlighted the challenge of meeting users' needs for custom virtual reality development, a role that most library staff are not trained for (Lessick and Kraft 2017). Curation and preservation of VR content in the face of software and hardware obsolescence, changing file formats, and the proliferation of discovery tools, metadata standards, and repositories, are also issues of particular interest to libraries (Cook and Lischer-Katz 2019). Some libraries have collaborated with researchers, community groups, and/or commercial development companies to build virtual apps that build off of their collections (Ovens and Mills 2018).

University of Calgary Implementation

The University of Calgary is a publicly funded post-secondary institution in Alberta, Canada, serving over 26,000 undergraduate students through more than 100 programs of study. Libraries and Cultural Resources provides collections and services to the campus community through a main central branch, the Taylor Family Digital Library, as well as six branch libraries.

Access to virtual reality equipment has been available out of the Taylor Family Digital Library since 2016. The Taylor Family Digital Library was opened in 2011 and contains a number of physical spaces that were purpose built to house technologies related to teaching and research in a central location: for example, a large scale visualization studio and four audio-visual editing suites (Libraries and Cultural Resources 2011). Virtual reality was not considered during the building's design; however, due to the expertise and interest in virtual reality in a staff

member, and the library's ongoing commitment to providing broad access to emerging technologies, discussion around setting up a dedicated space for virtual reality began in January of 2016. The first headset the library owned was an OSVR HDK1, which is an open source VR headset. Although it did see some use, the HDK1 was soon replaced with a dedicated space with a permanent installation when the HTC Vive became available for pre-order.

VR Studio: Permanent, Room-scale VR

The primary implementation of virtual reality technology in the TFDL involved repurposing a video screening room that was not being well-used for its original purpose. The room itself is 35m^2, and houses a room scale HTC Vive powered by a custom-built computer. In order to maximize library space, the room has been designed for two purposes: it also contains technology for recording video content against a green screen, using the One Button Studio setup developed by Penn State University (The Pennsylvania State University 2020).

The external sensors for the HTC Vive are permanently mounted on opposing walls. The defined play space within the room is the maximum supported size of 4m x 4m. The PC itself is a custom-built gaming computer with a 4.0 GHz i7 processor, 16GB of RAM, and a Geforce 980ti video card. This PC is housed within a surplus filing cabinet, which staff repurposed to secure the PC from tampering or theft. Several ventilation holes were added, as well as a port on the front where the cable box for the headset was attached. The headset and accompanying peripherals for the Vive as well as the keyboard and mouse are also conveniently stored in the topmost drawer.

The PC also uses a ceiling-mounted high definition projector as the primary display. This allows spectators to easily see what the VR user is experiencing, and is useful for training novice users. The projector screen is a retro-reflective cloth, which functions as a green screen when the

room is being used for video recording. A separate computer is housed within the room for the One Button Studio implementation (Figure 1).

The headset received a wireless upgrade in September of 2018. Removing the cable tether between the VR headset and the PC has allowed for increased safety and immersion. The video card was upgraded to a Geforce 1080ti at the same time.

The virtual reality studio is in an interior location of the library in a windowless, sound-dampened room. While ideal for experiencing virtual reality, it is isolated from staff areas and as such, library staff decided to limit room bookings to faculty, staff, and graduate students. Undergraduate students access the space through class visits, campus clubs, or if they can demonstrate a research need.

Figure 1: VR Studio: Space Configuration

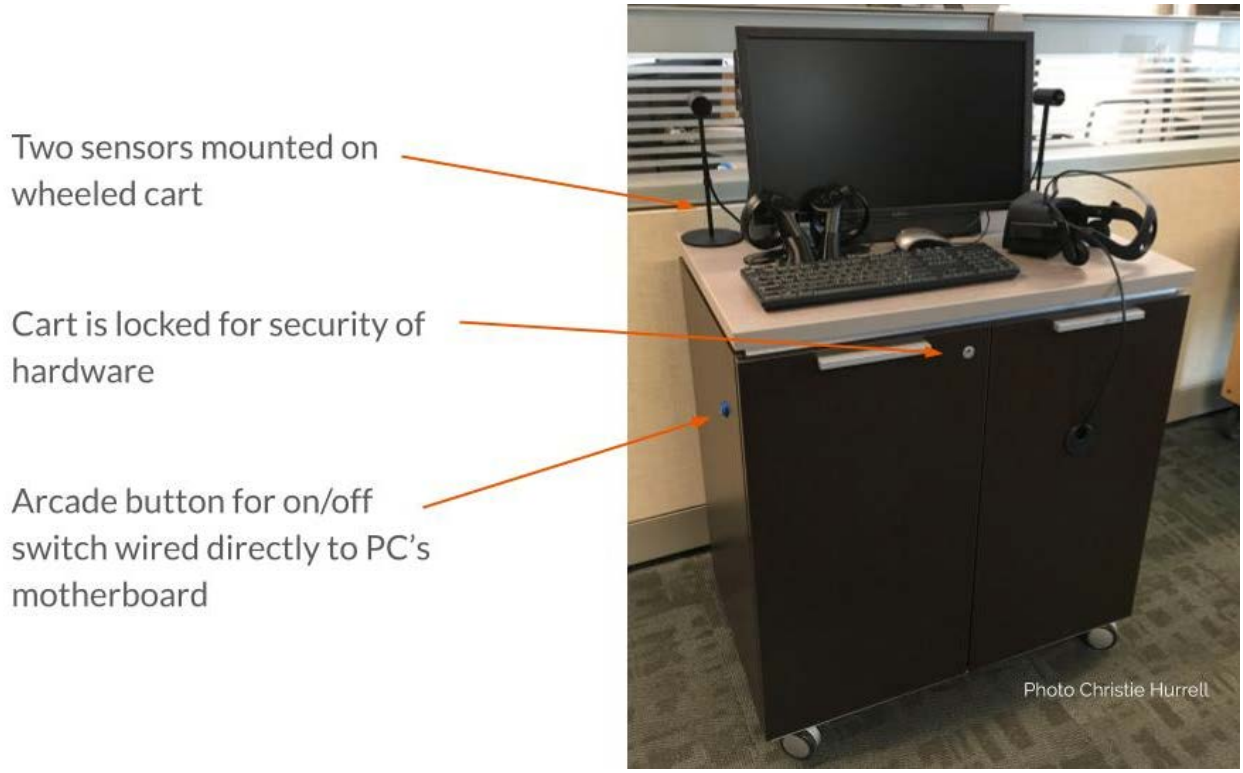
VR Cart: Semi-mobile VR

In 2018, in order to provide wider access to virtual reality experiences and to make better use of already-purchased equipment, a semi-mobile VR cart was developed and implemented that employs an Oculus Rift running on a custom made gaming PC. The cart was implemented

with minimal capital expenditures, and repurposed existing infrastructure and furniture as much as possible.

The cart itself is a repurposed cabinet on wheels; it has locked doors to protect the PC and a custom installed light up arcade button wired directly to the PC's motherboard, allowing users to turn the system on and off without accessing the PC directly. Two sensors are mounted on the cart, and additional components such as controller holders were 3D printed in the library's makerspace (Figure 2).

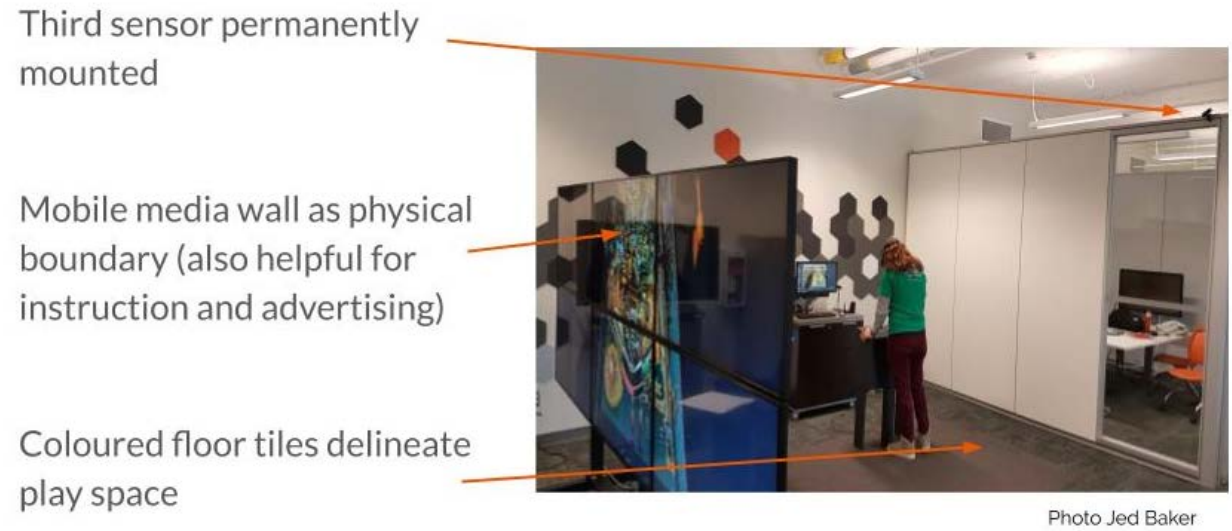
Figure 2: VR Cart Configuration



A semi-permanent location for the cart was set up adjacent to the TFDL's makerspace. This location was chosen for its close proximity to a staffed service desk, as well as to a large mobile media wall that can be used both as a boundary on one side of the virtual reality play space, and as a way to demonstrate to passersby the activities going on inside the play space. The cart is placed in a specific location and plugged into existing data and power sources in a floor

box. This keeps the room scale play area, which has been delineated by using different colored carpet tiles, in a consistent location between uses. A third sensor, which improves tracking of the user in virtual reality, was permanently mounted on the top of an adjacent workroom wall (Figure 3).

Figure 3: VR Cart: Space Configuration



Because the VR cart is located in an open, well-supervised area of the library, library staff felt comfortable opening up access to this technology to all affiliates of the university. It can also be used in other library locations with only two sensors, providing staff with a higher level of flexibility in programming and promoting this service. Due to the fragility of the equipment, the cart can be used in the library only.

VR Development Studio: High Performance Research and Development

The third Virtual Reality space in the TFDL is designed with VR development in mind. The development studio is a repurposed small group workroom, providing a more private environment. Inside the space is a high performance computer, a wireless HTC Vive, and several specialized user input devices.

The studio was created in response to user feedback. Many users requested multiple high resolution displays and increased computational and graphical capabilities suitable for VR development. There have also been requests for longer periods of access to the space. The current VR Development studio is a temporary location within the library, and is currently subject to reduced opening hours. It will soon be migrated to an adjacent space elsewhere in the library which will be bookable for longer periods of time and also accommodate users during any time that the library is open, typically 8am-11pm during the school year.

The development PC is equipped with dual 4K monitors, an Intel i7 9700k (4.9 GHz) processor with 32GB of RAM and a GeForce 2080Ti video card. The peripherals include a force feedback racing wheel and pedals, a throttle and flight stick, a flight yoke, and a custom built VR pinball arcade controller.

The current headset in the development studio is the original HTC Vive, which was migrated to the room when the main Virtual Reality studio was upgraded to a wireless HTC Vive Pro (Figure 4).

Figure 4: VR Development Studio: Space Configuration

In 2019, a self-contained Oculus Go headset was acquired, which represents the library's first investment in loanable VR equipment.

Streaming and Recording

Each of the virtual reality instances are capable of streaming the video output to other screens on campus, or recording a video locally. In one instance, this was used when viewing CT scans of fossils. The student could intuitively resize and reposition the virtual fossils, dictate observations and virtually write in the space. All of this could then be recorded, or streamed to an external site. The streams also serve to attract people to the VR cart's space. Content from the cart is mirrored to a high visibility media wall comprised of six televisions. Plans for the near future include integrating the stream with a large media wall located in the lobby of the TFDL, which sees heavy foot traffic throughout the day. Integrating the stream with the media wall's digital signage software will allow staff to stream VR content with minimal human intervention.

Outreach and Programming

The library uses an online reservation and booking tool to mediate access to rooms and equipment. Booking forms for the VR studio and VR development room (i.e. permanent spaces) require users to provide their status with the university when making a booking, as well as information on what they will use the room for. Access to the VR cart and the Oculus Go headset are mediated through the same booking system used for loanable equipment, which only requires users to provide their name and university e-mail address to book.

Bookings are mediated by trained student staff members, who provide users with access to the rooms and/or equipment and are also available to provide new or novice users with support in setting up the equipment, accessing apps, and navigating VR experiences. More in-depth training, class tours, and consultations are typically run by a permanent staff member.

Orientation to the VR development room is also performed by a permanent staff member, due to the lower volume of use and the higher degree of complexity involved in its use. Rooms are available for users to access when staff are present—typically business hours during the week and more limited hours during weekends.

Usage statistics demonstrate steady and consistent demand for virtual reality spaces and technology. Library staff have been keeping statistics for the VR studio since January 2017, and since that time the room has been occupied 43% of the time it is available. Only preliminary statistics for other VR spaces and technologies are currently available, but these will continue to be collected for future evaluations.

Organized tours, class integrations, and drop in sessions form a large part of the library's virtual reality programming: in 2019, 44% of usage represented organized tours for classes or other groups, while the remaining 56% of usage represents bookings made by individual patrons for personal use.

Undergraduate Class Integrations

Many undergraduate classes have used the Virtual Reality Studio as part of class tours, assignments, or drop-in "lab" visits. Some of the types of course integrations that have been supported are listed below. More information about the applications is included in Appendix A.

- Virtual field trips: Google Earth VR is an excellent application for exploring real life locations without having to fund expensive travel. Examples include German language classes touring historic locations, a Women's studies class studying the Stonewall Riots touring Greenwich Village, and Classics classes touring the Parthenon and other ancient Greek monuments.

- Immersive anatomy and physiology: These subjects are greatly enhanced through the immersive, experiential learning opportunities offered by virtual reality. Examples include optional, drop in sessions for second year kinesiology students studying human anatomy and physiology, as well as dedicated sessions for a dance anatomy course. Apps including ShareCareVR and 3D Organon are useful for teaching these students.
- Exploration of VR apps for content and form: Instructors teaching classes on media production in specific forms or genres have brought students to experience how these are adapted for the virtual reality medium. The studio has showcased VR apps using narrative and dramatic forms (e.g. Virtual Virtual Reality, The Gallery, Firebird – La Peri, and a Fisherman's Tale) demonstrated apps aimed at a young adult audience (e.g. Rec Room), and curated selections of apps that adopt conventions of manga (e.g. Holodance) for a variety of language and literature classes.
- Demonstrations of VR to prepare students for the workforce: For example, the instructor for the technology and the legal profession course sends students to experience virtual reality environments (the Blu) to prepare them for submitting or receiving evidence in a virtual reality format.
- Language learning: A local VR development company co-developed a Blackfoot storytelling and language learning app called Thunder VR for the Oculus Go together with an Indigenous youth services organization. Blackfoot is an Algonquian language spoken by a number of Indigenous nations in Southern Alberta, and is relevant to undergraduate courses taught in literature and linguistics departments.
- Hands on hardware comparisons: Students in an application programming course were able to use a variety of virtual reality headsets. They also had the opportunity to try out

different consumer and custom-built VR peripherals. After familiarizing themselves with the equipment, they were then able to discuss the technical, ergonomic, and ideological strengths and drawbacks of each of the consumer headsets. Some of these include performance versus cost, developer subsidies for application exclusivity on their headset versus software ubiquity, and how easily the hardware runs on third party platforms.

The large size of many undergraduate classes can be a barrier for integrating VR into classes. One strategy for alleviating this is to set up a variety of drop in times for students via the booking system; instructors can post these to the course management system and students can self-select a convenient time to drop in. The development of the VR cart has also relieved some of this pressure; with adequate staff support, library staff can divide classes into two groups to provide each student with more hands-on time with the equipment. However, reaching all undergraduate classes that might like to participate is still a challenge. Any class larger than about forty students cannot cycle all students through a VR experience using two virtual reality stations during a single 75-minute class, and asking students to attend drop in sessions in the library is not feasible for all classes. As others have noted, accommodating large classes requires significant advanced planning, as well as potentially scaling up the library's technological infrastructure (Cook and Lischer-Katz 2019; Putnam and Gonzalez 2018).

Workshops and Drop-ins

Curricular integrations are not the only way to provide undergraduate students with access to virtual reality experiences. Library staff have also offered extracurricular opportunities for students to experience virtual reality in a social, fun, and supportive environment. Initiatives have included:

- Weekly afternoon drop ins to promote the VR cart to undergraduate students, focusing on fun apps to encourage social groups and promote mental health. Once a month, these are moved to the main lobby of the library which has a high level of foot traffic, to draw in people who might not otherwise encounter it in its permanent location on the third floor of the library.
- Drop-in sessions using TiltBrush and Medium (virtual drawing and sculpting apps, respectively) targeting students who want to express their creativity in a different medium.

These opportunities are promoted via both the Library and the University event calendar, social media, and digital signage throughout the Library. Students appreciate the opportunity to participate in VR experiences in their library, particularly because most of them do not have access to these technologies in other parts of their lives. Students are increasingly recognizing the growing importance of virtual reality in a variety of fields and anecdotal reports demonstrate they feel more confident in using these tools after having time to experience them in a casual environment. A more formal evaluation of our virtual reality programming's impact on student learning and engagement is a future goal.

VR Artist in Residence Program

In 2019, the library staff primarily responsible for VR collaborated with a librarian colleague who has responsibilities for departments including Art History, Architecture, Planning and Design. Together, the team developed a call for virtual reality artists in residence. Prospective residents were asked to submit a short application describing why they wished to participate. The library committed to providing them with priority access to the equipment, in particular the VR development room, as well as dedicated staff time to become familiar with VR equipment, apps,

and software development tools. Of the two students selected to participate in the program's first incarnation, one is an undergraduate student in visual studies and architecture. The student indicated that developing expertise in virtual reality technologies, and their application to architecture in particular, would significantly enhance her learning and would also be a marketable skill in the job market. Library staff look forward to evaluating the results of this program in the future, and incorporating the experiences learned into future calls for artists and designers.

Conclusion

Offering undergraduate students access to virtual reality equipment and programming has allowed the Taylor Family Digital Library to expand its contributions to both curricular and extracurricular learning at the University of Calgary. By placing emerging technologies in a central location, supported by existing library infrastructure for promotion and booking, as well as by specialized technical staff and by librarians with connections to departments across campus, library staff have been able to reach a wide variety of students and expose them to virtual reality experiences. Some uses of the tools directly support their disciplinary learning, while other uses can add to their digital literacies and support pleasure, exploration, and mental health.

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Appendix A: Virtual Reality Applications

Application name	Developer	Academic subject relevance	URL
A Fisherman's Tale	Innerspace VR	English	http://afishermanstale-game.com/
Firebird - La Peri	Innerspace VR	English	https://store.steampowered.com/app/436490/Firebird__La_Peri/
Gnomes and Goblins	Wevr	English	https://www.gnomesandgoblins.com/
Google Earth VR	Google	Languages, history	https://arvr.google.com/earth/
Holodance	Narayana Games	Languages	https://holodance-vr.com/
Medium	Adobe	Art, Business	https://www.oculus.com/medium/
Organon3D	Medis Media	Kinesiology, Nursing	https://www.3dorganon.com/
PaulPaul	Another Circus	English	https://store.steampowered.com/app/892560/PaulPaul__Act_1/
Rec Room	Rec Room	English	https://recroom.com/
ShareCareVR	ShareCare	Kinesiology, Nursing	https://www.sharecare.com/pages/vr
The Blu	Wevr	Law, Computer science	https://wevr.com/theblu
The Gallery: Heart of the Emberstone	Cloudhead Games	English	https://cloudheadgames.com/episode-1-call-of-the-starseed/
Thunder	Mammoth XR	Languages	https://mammothxr.com/thunder.html
Tilt Brush	Google	Art, Geology, Astronomy, Architecture, Computer Science, Paleontology, Computer Science	https://www.tiltbrush.com/
Virtual Virtual Reality	Tender Claws	English	https://tenderclaws.com/vvr
VR pinball controller	Jeremy Williams	Design	https://www.tested.com/tech/gaming/569647-how-build-pinsim-virtual-reality-pinball-machine/