Central Regional Hub-funded project

Project Report

A Virtual Reality tool for Teaching Library Design

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Open Polytechnic
KURATINI TUWHERA

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Executive Summary

Currently students design libraries using insights from academic texts and personal experience with library layout design. The static nature of this makes it hard for students to envisage alternative design choices, in particular, the design of accessible libraries. With the aid of a grant from Ako Aotearoa the researcher coordinated the creation of a library in virtual reality (VR) for use in teaching the design of accessible libraries. Software was written by PointZero at a cost of $10,000. The user can 'walk' around a typical small library in which there are about ten barriers to access for people with physical impairments, such as books on high shelving, difficult staircases, objects blocking access, glass doors with no visible warning, and so on.

The software was used in conjunction with an assignment given to students of library management at Victoria University of Wellington. Student response was assessed in three ways. First was an informal review of the assignments, which showed some barriers were easy to spot and others were noticed by only a few students. The second stage was an online survey that focussed on issues such as ease of download and the ease of control. This found the software to be easy to use. One problem that stood out was how many students reported feeling nausea, a common problem with VR. The third stage of assessment was interviews with four students. This showed students felt using VR was novel and fun, and that it forced them into a different way of thinking about a problem than they might have done by learning from traditional sources such as text.

The software is flexible and barriers can be switched on and off, though it is not actually open source. This project supported the creation of a virtual reality application. A video of the application in use shows what the end-user can see on screen prior to directing their own movements around the VR Library. It is now being used by the Open Polytechnic. Other institutions are welcome to approach the researcher.

Project Objectives

New technology opens up the possibility of teaching library and information studies (LIS) in ways not previously imaginable. This paper is a report on a project conducted at Victoria University of Wellington (VUW), New Zealand that used virtual reality (VR) in the teaching of library design, specifically, designing accessible libraries for people with physical impairments. Research into student opinions of the use of VR is needed because we do not yet know for sure if the use of VR for teaching actually improves student learning when compared to more traditional methods. The central question asked is "does VR help the teaching of library design?" There are many ways that library design could be taught and the use of VR is only one option, so it will be helpful to have some assessment of how effective it is as a teaching method. It will also be useful to know if VR can be delivered efficiently and at an acceptable cost, and how students respond to being asked to use VR for assessed work. This study evaluated student perceptions of VR used to teach library design; it has identified areas in which the current VR tool needs improvement and where it has been proved to be effective.

Literature review

It is an axiom of library services that library buildings should be open and accessible by all. In practice this has not been implemented as well as it should have been. Copeland (2011) makes it clear that many 'differently-abled' customers find it hard to use libraries in their totality, some parts being easy to access while others are inaccessible. Staff must be trained to provide better services to people with disabilities, says Grassi (2017) and they must be

trained to identify how services can be improved. How can this training be done? Fortunately there are several sources that can aid the design of accessible libraries. The International Federation of Library Associations and Institutions (IFLA) guide by Irvall and Nielsen (2005) is a simple starting point, and there are recent books by Kowalsky and Woodruff (2017), Vincent (2014), and the edited work of Wentz, Jaeger and Bertot (2015). The literature is available therefore, but it is uncommon, to say the least, for LIS students to be given specific exercises on designing accessible libraries; no example of this was found in the global literature review. That was the underlying justification for this project.

All the references given above were used as sources for this project, along with the author's personal observation in several different libraries around the world over a period of years. The author also gathered input from many members of the library profession in New Zealand through the widely used email discussion list 'nz-libs'. The author sent a message to the list inviting information about ongoing barriers to physical access in libraries. There was a high number of responses, which in one way was a sign that there was interest in the subject, but in another way it was disconcerting because it showed how many libraries still had unresolved problems of accessibility, such as book return chutes positioned too high for many customers, heavy doors that are hard to open, students with autism who are affected by unexpected noises, mechanical spring push-button timers for lighting, and so on. Many of these were incorporated into the VR Library. Respondents also gave interesting evidence that problems can be 'dynamic' and not easily solved by design alone, such as adjustable height tables that are 'colonised' (using the word of the respondent) by able bodied customers.

Virtual reality

Virtual reality is an artificial environment created with the use of computer software; typically it is experienced through sight and sound. The most obvious benefit of VR in education is that it allows the user to explore a designed world that resembles the real world

within which there can be challenges to overcome or puzzles to solve. The user can 'see' concrete information that is [or should be] perceptually easy to process. For some, but perhaps not for everyone, this visualisation might make it easier to appreciate problems and suggest solutions than if exposed to the questions through more traditional media such as print. There are different types of VR, and a simple classification starts with the difference between non-immersive environments in which the designed world can be viewed on a flat screen with movements controlled by mouse, keyboard, touchpad, etc. and immersive environments in which the user is completely surrounded by the designed world, usually requiring a head-mounted display. Another way to differentiate types of VR is whether they are online or offline; the advantage of offline, according to Lee and Wong (2008), is that it should be able to deliver better modelled objects. For reasons explained later, the VR Library created for this project was non-immersive and offline, and students could not interact with each other in the virtual world. Since Lee and Wong wrote in 2008 there have been considerable improvements in computer technology and much better bandwidth and security in the cloud so it ought to be possible to create online virtual reality that has really smooth interaction. This is a possible topic for future research

Pedagogy of VR

Behind some of the claims made for using new technologies in LIS teaching is the assumption that younger students are more familiar with new technologies, and "there can be a heightened level of knowledge and understanding of the virtual world and its electronic offerings brought to a generation, many of whom were raised on electronic devices and all of the enrichments that technology can provide" (Massis, 2015, p. 798). As Fowler has said (2015), most of the literature on using VR in education has been descriptive and has omitted reference to pedagogy; where it has been mentioned the learning style is nearly always based upon constructivism or variants of it such as problem-based learning. Dalgarno and Lee

(2010) developed a model based upon the potential of VR technology that identified learning benefits of spatial knowledge representation, experiential learning, engagement, contextual learning and collaborative learning. All of these could have been relevant to the VR Library project, though as 'affordances' they show potential rather than actual learning outcomes. Fowler (2015) blended the Dalgarno and Lee model with some pedagogical criteria, such as the framework from Mayes and Fowler (1999) to produce a learning model that was more directly applicable for educators designing learning activities. In the Mayes and Fowler framework there are three stages starting with Conceptualization, the learning of new facts and theories, then Construction, which involves evaluating facts and solving problems, and finally Dialogue which involves critical thinking. The practical application of this framework lies in how higher level design decisions are made. As an example, a designer of a VR solution must choose the mix of virtual and real-world educational experiences. In this VR Library project the use of VR in teaching started with traditional methods of instructor-led seminars and recommended reading; only when the students were familiar with the concepts and previous thinking on the subject were they 'scaffolded' to the project-based learning method using the VR tool created specifically for an assignment. Interestingly, research (Lee, Wong & Fung, 2010) has suggested there is no significant difference in the cognitive and affective learning outcomes for students with different learning styles in the VR-based learning environment so that was not a factor deliberately observed in this project.

Previous use of Virtual Reality in education for librarianship

Staff of the School of Information Studies at Charles Sturt University created a presence in Second Life, an online virtual world from Linden Labs created in 2003, which was used by students for a variety of purposes. Faculty noted that considerable time was needed to create avatars, and so on, to make Second Life usable for teaching purposes, but the positive benefit was it provided a good platform for communication with distance students, though large

classes (more than about 15 students) became hard to manage. Students spoke of being in a 'real' classroom and interact freely with others, though the issues of limited bandwidth and a difficult interface to master were obstacles for quite a few students (Hay & Pymm, 2011). Rahim (2013) described a collaborative project between Temasek Polytechnic (Singapore) and The Hong Kong Polytechnic University. Both institutions already had a presence in Second Life so the project arranged for students to meet up and network amongst themselves using avatars and interactive 3D objects. It was found that the interactive 3D environment within Second Life promoted student-centred learning because it was more engaging, fun and interesting, thus increasing student motivation. It could also help develop their abilities to develop relevant problem solving skills and knowledge. Students provided positive feedback that indicated their learning in this medium was motivated because it was fun, engaging and interesting. Rahim said that because they were motivated it boosted their confidence level and sense of empowerment in their own learning.

What was different about the current project was that it was very focused on a specific learning objective; that is, students learning how to design accessible libraries. It might have been possible to do this in Second Life, and it is acknowledged that if it had been done that way there would have been potential for more interaction amongst the students and possibly even cooperation with students in other library schools. It was decided, however, that the overheads of using Second Life, both to the University (e.g. creating avatars) and to the students, was too high; for example after asking the students at VUW if they used Second Life it became obvious that very few did, so they would have had to learn a whole new virtual environment for a single exercise. By designing the VR Library from scratch it made it possible to focus on the precise learning objective, as stated above. This has its complications, of course, and it may be a more expensive option. These are matters for the evaluation to assess, so some comments on this will be made later in this report.

Evaluation design

SECTIONS

This research project needed some structure on which to base the assessment of effectiveness of using VR to teach library design. The model chosen was SECTIONS written by Bates and Poole (2003). This mnemonic is built up from:

- **S**tudents: what is known about them and the appropriateness of the technology for this group?
- **E**ase of use and reliability: how easy is it for teachers and students to use, and is it reliable when deployed?
- **C**osts: what is the cost structure of the technology, e.g. for creation, implementation and/or maintenance?
- **T**eaching and learning: what kinds of learning should take place, and what instructional approaches will best achieve that?
- **I**nteractivity: what kind of interaction does the technology support?
- **O**rganizational issues: what are the requirements and/or barriers for this technology to be used within the organization?
- **N**ovelty; how new is this technology and how do students respond to its newness or otherwise?
- **S**peed: how quickly can courses be mounted with this technology?

For this research the most important criterion is 'Teaching and learning' though 'Students', under which issues of ease of access are subsumed, played an important part in the initial thinking and also needed to be evaluated. 'Interactivity' and 'Novelty' were also very

important. The other criteria were examined but were not considered as crucial (and the results proved them to be less important).

There are some points that can be dealt with immediately. The students in this study were all studying at a distance. This determined that no advanced/expensive equipment such as a head mounted display could be required for the assignment, and that is why the decision was made to create a non-immersive and offline tool. Students used their own computers or, with permission, computers in their workplace. Generally these would all have been relatively recent Windows or Macintosh computers, though no check was made on this. The VR Library was created for a postgraduate professional course and many of the students were working in libraries while studying; later on it can be seen how this helped some of them to think about physical barriers to access in their own libraries. Costs had to be contained because this project was for one relatively small assignment in one course, though the grant from Ako Aotearoa helped enormously. As a result of the decision to make the VR Library an offline tool the relevant files had to be stored on a University server and download links given to the students; this was the only significant Organizational issue in the project.

Creating the software

With a grant from Ako Aotearoa the author commissioned Wellington software developers PointZero to create the teaching tool, which from here on will be called as the VR Library. It was written using Maya, Unity Game Engine, C# and Keyshot. Both a Windows and a Mac OS version were made. The size of the application unpacked was about 100 MB but in a zip file it was only 37 MB. It was stored on a university server and download links disseminated to the students. Students used their own computers, as explained above.

The VR Library as it was created for this project has three floors joined by an elevator and two staircases, one of them particularly steep. The barriers in the VR Library that were designed to be found included the considerable height of some shelving bays, some bays too close together for wheelchair access, shelves put too close to columns that barred access, stairs too steep, glass doors with no visible marking, car parking for the disabled in an inconvenient location, and so on. Consideration was given to simulating the experience of wheelchair user moving about the virtual space but this was rejected because it is unethical to suppose that one can simulate the experiences of a wheelchair-bound person. Instead, it was understood that the purpose of the exercise was to help students identify barriers to access, so logically the 'eyes' of the user had to be those of a typical library staff member, hence the experience of the VR Library is that of a person of about 1.70 meters tall. This aided identification of barriers of height (shelves, desks, etc.) and as an additional measurement aid a wheelchair was placed in the library.

For an assignment the students were required to write a short report that listed and described the barriers they found, to suggest ways of removing or alleviating the barriers, and finally to

analyse what impact their proposed changes would make on the library, e.g. the effect on available space, services, and cost.

Methodology and data collection

There were three different stages of data collection. First, while marking the assignments it became very apparent to the course coordinator (who was also the researcher) that some aspects of the VR Library were clearer to the students than others, for example, all students could see the problem of high shelving, but very few saw how toys or bean bags casually strewn around the floor could create temporary barriers for people with mobility problems. While not part of the formal assessment of effectiveness, this information has provided useful feedback that will enable the design of the VR Library to be improved for subsequent use. Second, data was gathered through an online survey created in Qualtrics; the instrument consisted of seven simple questions on ease of access and ease of use (categories from SECTIONS), followed by one more open-ended question. The questions are attached as an appendix. There were forty responses out of a possible 82 students who completed the assignment over two iterations of the course (a response rate of roughly 49%). Third, four students agreed to be interviewed with the purpose of gathering more in-depth information about their opinions of the VR Library as a learning experience.. The interviews were conducted by a research assistant and the identity of the students interviewed is not known to the author and never will be, as it was assumed students might not give wholly honest answers to questions posed by the instructor who not only taught the course but had instigated the creation and use of the VR Library. More participants would possibly have been beneficial but all four interviewees gave very consistent responses to the interviewer so this gives some confidence that the small number is not a major limitation of this evaluation.

Results

The most obvious barriers to access, such as the height of some shelving bays and the lack of adequate width between other bays were most often seen by the students. Other height/width barriers were also spotted and described. Issues such as the location of the disabled car parks were also commonly noticed. Less obvious barriers were only occasionally spotted. The elevator does not arrive flush with the floor but this was hardly noticed at all. Students who did not turn on their computers audio missed the alarm and so did not realise that there was no visible confirmation of the alarm for people with hearing impairments.

The survey data was mostly reassuring. Ease of access was not a problem; only three of 40 responses suggested any difficulty in being able to use a suitable computer, one respondent said there was some difficulty with the download (possibly a firewall); two students had difficulty decompressing the zip file; two students said the size of the file was an issue for download. Answers to the questions about Ease of use and reliability revealed some issues with the VR Library; a little jerkiness of the movements, for some the instructions were not completely clear, and a rather disturbing six out of 40 said they felt uncomfortable (e.g. nausea) as a result of moving around the VR Library. Nausea is sometimes experienced by users of virtual reality and there is no obvious remedy, so this has to be taken into account for the use of VR as a teaching tool. The open-ended comments mostly reinforced concerns about the jerkiness of movement and an occasional experience of nausea. Another issue that was spotted was the difficulty of switching between the VR Library and other applications, which slowed up students typing notes on the same computer; this has been fixed.

In the interviews the questions were more focussed on the educational benefits of using VR. Relevant to the SECTIONS criterion of Teaching and learning, students said:

“Humans are visual creatures. Better to see than to try to interpret measurements given in a book.”

“Way easier than text or video because you could walk around, look down, go back, and push the buttons.”

“It put everyone on an even playing field because not everyone works in a library. We all had the same design to focus on.”

The last comment above showed how the learning went beyond the immediate identification of the barriers because solving problems became almost ‘real’ to the students. Some thoughts on making the experience seem ‘real’ are given later. Other comments emphasised how problem-solving became more immediate in the VR environment:

“Making you put a different hat on …”

“It raised a few questions in my workplace [about accessibility].”

“It made me think about accessibility over functionality.”

On Interactivity the dominant reaction was that the students did not like group work in general and would not be keen to do this assignment collaboratively. On Novelty, however, the responses were entirely positive. This reinforced the findings of Rahim (2013) that using this sort of technology motivated students, made them feel empowered, and boosted their learning experience.

“Never done this type of thing.”

“Good to do something different. More enjoyable and interesting.”

"Yes, motivated me. Completely new, different, interactive. Kinetic learning, which you don't often get in university study."

Discussion

The decision to provide the VR Library as an offline application that could run on Windows and Mac OS seemed to work well, though some students needed to use computers at work simply because they simply do not own a desktop or laptop computer with sufficient capacity and a large enough screen to enable smooth running of the application. This could become a more serious consideration in the future as more people rely on small form devices as their only computers. Until head mounted displays become both more common and much cheaper it is unlikely that the current VR Library will be made more immersive. A flat screen display will have to suffice for the short-term, though a future project could investigate the use of a more 'immersive' reality for teaching different topics in library management.

It is clear from the interview data that students enjoyed the novelty of using a VR application; the kinetic nature of appearing to move around in a virtual space was said to be more enjoyable and motivating than conventional forms of university study. The novelty can be expected to last for a time but eventually it might fade.

Students said that being able to 'see' the barriers helped them appreciate them more clearly than they would expect to learn from reading. As an example, shelving too close for wheelchair access was easier to visualise as a barrier to access rather than trying to interpret measurements in a book. This sort of learning activity fits into the first 'conceptualization' stage of Mayes and Fowler's framework (1999).

The second stage of the learning designed for this project was problem-solving. Statements from students showed that they were actively thinking about the barriers they found in the VR Library with the intention of removing or alleviating them. The problem of dealing with a space that can only be accessed by steep stairs made a few students think laterally about how the building could be altered to solve the problem, so this fits neatly into the second 'construction' stage in the Mayes and Fowler framework (1999).

The intention of the project was to evaluate virtual reality as a tool for teaching library design. The students 'walked' around a library so their experience of it was rather static, that is, not much happened during the interaction, though some sounds were used. Could the application be made more immersive to enhance student engagement? Higher quality graphics, more sounds, and possibly more action could help make the library seem more 'real' to the student. Perhaps it would, though a design application is never going to need true 'suspension of belief'. It would be more useful in teaching issues that involved human responses to unexpected and unwanted situations – an angry customer, for example. Virtual reality has been used to put people into 'stress' situations so that they can develop coping responses in advance (e.g. Crescentini, Chittaro, Capurso, Sioni, & Fabbro, 2016). This could be done for librarians, who, contrary to the public belief, are quite often confronted with angry and/or disturbed people. This could be a research project for the future.

The costs of creating a VR application might appear to be high, depending upon the quality of the developers, but no higher than a good video production. What needs to be considered is how often the VR application can be used. In the first version of VR Library the barriers were 'built-in' meaning it cannot be used again unless the instructor accepts that some students will pass on very large hints to friends taking the course in later years. The second version, funded by Ako Aotearoa, was built with twelve barriers that could be rotated in and out by the owner of the software to make it viable to use the VR Library over a period of time.

Examples of barriers that could be switched on and off were; the audible fire alarm, dead-end aisles between shelves, access to the study space via the steep stairs, the location of disability car parks, and stickers on the glass doors. While the original intention of this was to make the application usable over a period of two or three years, such 'randomisation' can have other uses in teaching. A student could, for example, be asked to identify some very obvious barriers as a first step, then, once that level of difficulty has been mastered, more difficult barriers can be made visible for the next phase of learning.

Earlier it was pointed out that some students work in libraries. Seeing barriers to access in the VR Library has helped some of them to appreciate design failings in their own libraries, though it should also help them analyse ways to remove or alleviate those barriers, which in reality are not always easy and cheap. Overall, the use of VR has made the teaching of library design more effective, though more research and experience in its use will be helpful.

Future use

Use by other institutions

Ako Aotearoa want their funding to be of wider benefit than to just one institution. The VR Library software can be used by any institution, though there are some limitations to this. Version 3, which contains the twelve option to turn barriers on and off, can only be controlled by the 'owner' of the software (currently, that is the researcher), so an institution that does not communicate with the researcher would not be able to change the software in any way. This could, of course, be changed if a new and genuinely 'open' application can be developed. The Open Polytechnic has chosen to use the VR Library in one of its courses for 2018-2019. The course is LIS702 Strategy and Planning in Information Organisations. Students have been asked to walk through the library and identify barriers to access and

hazards as part of a section on considerations for space planning. It is not being used as part of summative assessment.

Use in head mounted displays

The VR Library software was written in standard languages that are all commonly used for writing immersive VR software, this would make it possible to convert the VR Library to a much more immersive experience for users with head mounted displays. As was said earlier, the cost of such displays is still high enough that it seems unreasonable to expect students to purchase one, though if the software is used 'on campus' then an institution could supply a few displays for their students to use. Bandwidth is continuing to improve to the extent that future projects might consider online interaction.

Open software

The software is not truly open and it is unlikely that any organisations would pay to make the current version of the VR Library open so that institutions could make it very flexible; examples of what might be done are moving furniture around, adding or deleting furniture, extending the building, and so on. If this could be done then uses could be flexible, not only in education but in staff training, for example. If there was sufficient interest, a new 'open' version could be funded by a consortium of interested organisations. As a result of this Ako Aotearoa funded project, enough is now known about the use of VR in LIS education to build a very successful and innovative new tool.

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Appendix 1: The online survey questions

Did you have access to a computer that could run the VR file and that has a large enough screen? *Please check one only.*

- Yes, I had easy access to a Windows computer
- Yes, I had easy access to an Apple computer
- I had access to a Windows computer but it was not easy for me
- I had access to an Apple computer but it was not easy for me
- I had no access to a Windows or an Apple computer

Could you download the VR file to the computer you mentioned in Q1?

- Yes, I could download the file easily
- I could download the file but only with some difficulty, e.g. because of a firewall.
- I could not download the file at all.

Was the file size a problem or a concern for you, e.g. because you have a cap on home Internet use?

- Yes
- No

If you said No, please say why, specifically.

Was it easy to install the VR file?

- Yes, I installed it easily
- No, I had some problems installing it / I could not install it.

Was it easy to use the VR file?

- Easy
- A little difficult
- Very difficult

Did the VR file run smoothly?

- Yes, all the time
- It froze or ran oddly at times
- It gave a lot of trouble

Did the instructions provided on Blackboard help you control your actions within the virtual reality?

- Yes, a lot
- Partly
- No, I still have difficulty with the controls

Did you feel uncomfortable while within the virtual reality?

- No
- Yes

Appendix 2: Indicative questions for semi-structured interviews

How long did it take before you felt you could control your movements around the VR Library? Or did you never feel fully in control?

Have you played games on your computer before and did this help you use the controls?

Have you used virtual reality much before? Was this on a desktop or laptop computer, on a small hand-held device, or using special equipment (e.g. a helmet)? If so, do you have any preferences for how you would like to use VR for learning about library design (or similar)?

Was the VR Library a useful tool for learning about library design, especially barriers to access? [Was it easier to appreciate the barriers – or harder – than other forms of learning, such as text or video?] Can you give an example to explain your response?

Would you prefer to do this more as a text-based exercise, i.e. by reading about it? Do you think a video and/or photographs would be better as a means of learning than the VR Library? Can you compare your response by using examples from other courses you have taken I the past (not just information studies courses)?

If you liked the VR Library as a means of learning about library design, can you say why? Did it motivate you more than some other forms of learning might do?

If you did *not* like the VR Library as a means of learning, can you say why?

Have you done more to learn about library design since completing the assignment associated with the VR Library?

How much did the assignment help you learn about library design for customers with impairments?

Would some other form of assessment be a better match with the VR Library than a report?

As this assignment used a relatively new form of technology, did you feel there was enough interaction with the lecturer before, during and after the assignment? If there was not enough, what sort of interaction do you feel you needed more of?

Would you like to do this sort of exercise in a group, that is, make it a social learning activity?

Did the assignment encourage you to think about solutions to problems of access in ways that you might not have done if you were learning using texts and photographs? In other words, did the visualisation of a 'real' library help you to appreciate the outcomes of your decisions?