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# Fast Cars and Fast Learning: Using Virtual Reality to Learn Literacy and Numeracy in Prison

**Jimmy McLauchlan**
Methodist Mission Southern, New Zealand

**Helen Farley**
University of Southern Queensland, Australia

## Abstract

Virtual reality has the potential to vastly improve the experience of education for incarcerated learners, particularly those with limited levels of numeracy and literacy. It is estimated that nearly two-thirds of prisoners in New Zealand lack the functional numeracy and literacy they need to fully participate in everyday life. Many have had sub-optimal experiences with formal education, often leaving early and disengaging fully with education. Many more suffer from a range of learning challenges brought about by traumatic brain injury, fetal alcohol spectrum disorder, attention deficit hyperactivity disorder, and a range of other conditions.

The Methodist Mission Southern was contracted by the Department of Corrections New Zealand to deliver intensive literacy and numeracy training to prisoners in one of the country's southernmost prisons. They have partnered with Animation Research Limited to design and deliver a literacy and numeracy program contextualized within a virtual mechanic's workshop using virtual reality and tablet technologies.

Data was collected through semi-structured interviews with participants and was analyzed using a thematic analysis. Gains in literacy and numeracy were also identified through a standardized literacy and numeracy assessment tool. Initial results from the pilot project are encouraging with all participants showing gains in their literacy and/or numeracy scores. Learner engagement was heightened, with all reporting positively about the program. Future iterations of the project are planned to accommodate higher-level learners and alternate scenarios.

# 1. Introduction

With good reason, correctional jurisdictions have traditionally been conservative when considering implementing educational technology initiatives within the prison environment (Farley & Doyle, 2014). For the most part, prisons are primarily designed and built with custodial security as the overriding priority (Farley, 2018). Even so, a number of jurisdictions around the world are beginning to implement innovative technology programs for education. These include the Making the Connection project in Australia, which uses internet-independent laptop computers for prisoners to use in their cells to provide access to digital higher education from the University of Southern Queensland (Farley & Hopkins, 2016). Beginning in 2013, this project is active in Queensland, Tasmania, Western Australia, and the Northern Territory and has had around 1700 course enrolments with better retention rates and slightly better results than for non-incarcerated students (Farley & Willems, 2017).

Some jurisdictions are going even further and are employing virtual reality initiatives for rehabilitation, education, and reintegration (Farley, 2018). Even so, there are only isolated pockets of VR innovation happening around the world, and there are no widescale deployments of VR in prisons for any purpose, educational, or otherwise (Farley, 2018). There are a number of reasons for this: 1) correctional jurisdictions are necessarily risk-averse, and VR hardware is thought to introduce an unacceptable degree of risk; 2) many VR applications require internet connectivity, and this is forbidden in most correctional jurisdictions; 3) VR hardware and applications are sophisticated and expensive and beyond the means of many educational providers and correctional jurisdictions, and 4) VR applications are labor intensive to run and supervise making them prohibitively expensive for most education providers delivering into prisons and for the correctional jurisdictions themselves. However, it is risk aversion that is the biggest hurdle to overcome in the introduction of virtual reality into prisons resulting in very few examples of its use in this context.

In 2017, prisoners in the Fremont Correctional Facility in Colorado who had already served 20 years of their sentences and had been detained as juveniles, were entered into a program to prepare them for life on the outside (Dolven & Fidel, 2017). The program made use of VR that the prisoners accessed via headsets and hand controllers. The program taught them about money management and computer skills. Another benefit was the ability to show the prisoners how much the world had changed since their imprisonment. For example, they were able to learn how to use a self-checkout at a supermarket (Dolven & Fidel, 2017).

In another project called *Back Home*, Chilean filmmaker Catalina Alarcón created videos of the families of twelve female prisoners at San Joaquin Women's Penitentiary in Chile. Over six months, Alarcón arranged for a 360-degree camera to film inside the homes of the participating prisoners. Family members were included in the videos, often doing everyday tasks such as cooking dinner. Towards the end of the project, Alarcón allowed the prisoners to watch the videos using VR headsets. The aim was to help these prisoners reconnect with the outside world. In the future, she hopes to be able to stream the footage from the 360-degree cameras to prisoners in real time (Knowles, 2017).

Vocational education is commonly delivered in correctional settings as it is widely recognized that post-release employment decreases an ex-prisoner's chances of offending (Manudeep et al., 2016). However, given the nature of the carceral environment, it can be difficult to recreate those environments that will sufficiently contextualize vocational education. A chef will learn best in a kitchen, and most prisons do have kitchens in which this education can occur. However, it can be challenging to provide suitable environments for a range of other occupations such as carpentry, forestry and so on.

Virtual reality environments may be one way of making learning meaningful and engaging through contextualization (Farley & Steel, 2009) for a cohort that has largely disengaged from learning. Before coming to prison, some 32 percent of prisoners had not completed junior high school and have had negative experiences with education, very often due to undiagnosed learning difficulties (Skues et al., 2019).

Outside of the corrections environment, the benefits of virtual reality for education have been well documented (Massis, 2015; Freina & Ott, 2015). In addition, it has long been recognized that learners need new literacies to exist and thrive in the digital world (for example, see Sherman & Craig, 1995; Coiro, 2003). Though there have been articles speculating on the benefits of virtual reality for literacy and numeracy education, we have been unable to locate specific examples of this work being undertaken. For example, in 2016, authors Pilgrim and Pilgrim posited that VR would be well-suited to teaching literacy and numeracy in the classroom as it would enable virtual field trips that would prove to be engaging to learners, particularly if the focus of that field trip was something in which they were interested and/or something with which they had prior experience. We believe that there most likely work being done in this space but that educators have not sought to document or collect research data on this work.

Similarly, the social services agency Methodist Mission Southern (MMS) believed that VR could increase engagement with literacy and numeracy education. They had been engaged by the Department of Corrections New Zealand to deliver literacy and numeracy training into the Otago Corrections Facility (OCF) (Methodist Mission Southern, n.d.). They believed that their learners would learn better when they are presented with images about a topic with which they were already familiar (Pilgrim & Pilgrim, 2016). MMS and Animation Research Limited (ARL) designed a virtual reality literacy and numeracy pilot project contextualized within a virtual mechanic's workshop, at OCF on the South Island of New Zealand. More familiar with recreating sporting animations for high profile sporting events such as America's Cup, Animation Research Limited is a computer graphics production house, turning digital data into pictures. ARL specializes in real-time 3D sports graphics, 3D television graphics, 3D stereographics and 3D data visualization tools.

The goals of the pilot project were to determine if enabling users to enter into an immersive virtual environment through VR technologies, would increase their engagement with contextualized numeracy and literacy learning, and would promote learner progress. Prisoners, often because of their negative experiences with education and undiagnosed learning difficulties (Skues et al., 2019), are reluctant to engage with literacy and numeracy education while incarcerated. In addition, to show a 'weakness' in learning can leave prisoners susceptible to ridicule by other prisoners. Many would rather avoid engagement with learning than expose themselves as 'dumb' (Ricciardelli, Maier & Hannah-Moffatt, 2015). For these reasons, it can be difficult to get learners to attend classes. Increased prisoner engagement with learning would lead to better attendance in class and increased participation in activities. The pilot project was also designed to determine whether or not it was viable to deliver numeracy and literacy education using VR technologies in the longer term and to more prison sites.

## 2. The Cohort and Technology

In New Zealand, numeracy and literacy levels of learners are measured in steps 1 to 6, with learners at step 1 being able to read simple one and two-syllable words, and learners at step 6 able to read more confidently, and being able to read more complex words and sounds (Ako Aotearoa, 2019). Learner literacy and numeracy is assessed using the LNAAT (Literacy and Numeracy for Adults Assessment Tool) which is a standardised assessment tool (Tertiary Education Commission, 2019). The LNAAT helps educators improve the literacy and numeracy skills of their learners. It does this by providing robust and reliable information that educators can use to understand learners'

literacy and numeracy skills and their progress. This tool can assess adult reading, writing, numeracy and vocabulary skills. The LNAAT is a key component of the national literacy and numeracy resources that have been developed by the New Zealand Tertiary Education Commission (Tertiary Education Commission, 2019).

For this pilot project, learners at steps 1 and 2 were recruited. MMS was contractually obligated to focus on learners assessed at steps 1 and 2 of the LNAAT, so these learners were the focus of the project. In New Zealand prisons, some 60 percent of learners are considered to have literacy levels that would prevent them from fully participating in life outside of prison (Department of Corrections, 2017).

Learners with neurodiversities are overrepresented in the prison population in most jurisdictions. It is estimated that up to 60 percent of learners suffer from one or more neurodiversities such as dyslexia, acquired brain injury, fetal alcohol spectrum disorder among others (Jones & Manger, 2019). In many cases, this is why these learners are assessed at such a low level for numeracy and literacy. A project currently underway within the Department of Corrections in New Zealand will screen for some of these neurodiversities, particularly dyslexia (Stewart, 2019).

During the development of the virtual environment, the VR technologies were taken into the prison, where an advisory panel consisting of 12 prisoners gave feedback on the technologies, activities and the environment. The development team incorporated the panel's feedback into the design of the environment which was crafted using Unity. Unity is a widely-used game development software platform that is used to build high-quality 3D and 2D games and deploy them across mobile, desktop, VR/AR, and consoles. It was selected because of its quality as a development platform and because it is a familiar tool for the development team and future developers required by the project.

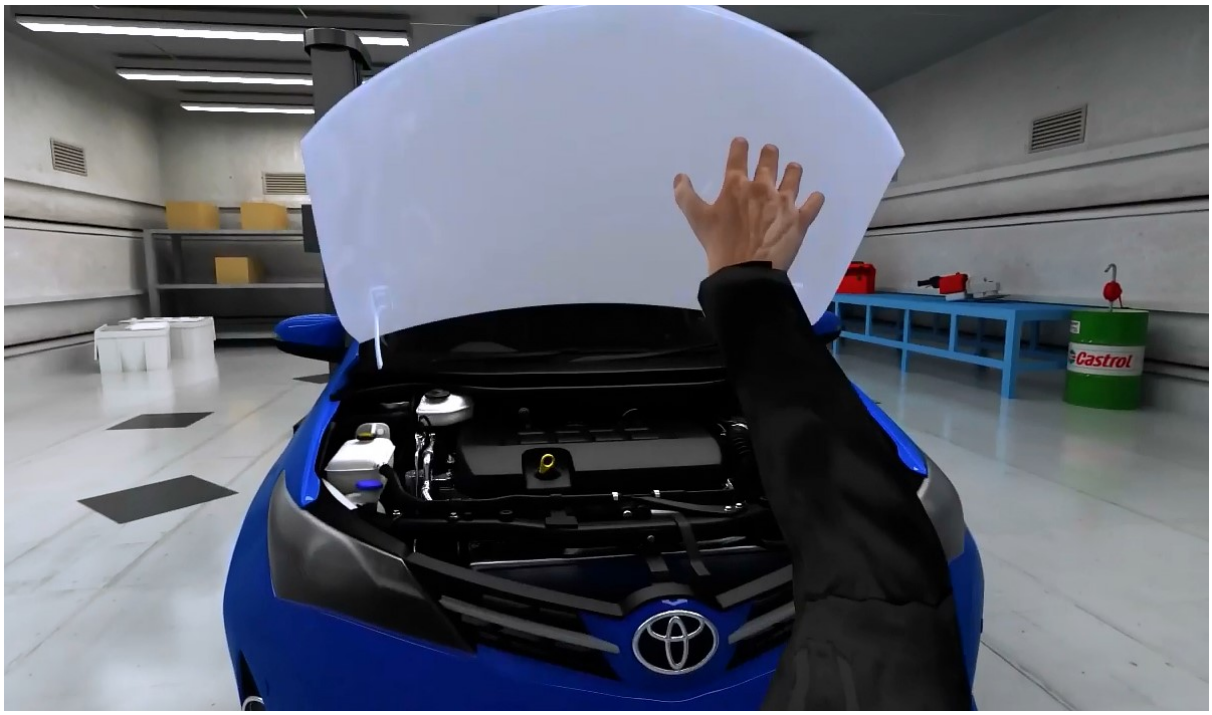
The environment was co-designed with prison-based learners based on their original concepts for a mechanics-based setting for contextualized literacy and numeracy learning. The construction of the VR garage environment was an interactive process undertaken by a small team of educators, software developers, and prison learners via several user testing sessions over 12 weeks.

The prisoners who participated in the pilot project were selected by the Department of Corrections, New Zealand. Security classification, sentence length, location within the prison and LNAAT score were considered when selecting suitable participants. Priority for literacy and numeracy education is given to those with very low levels of literacy and numeracy (steps 1 and 2). Those participants must have exhibited a certain standard of behavior and not be currently eligible for psychological or criminogenic programs which are given priority over education. Prisoners of different security classifications cannot mix, and prisoners involved with different gangs cannot mix due to security concerns. The participants in this pilot project met all these criteria which are more to do with security and managing risk than suitability for a technology pilot. Some 9 learners participated in the project, 3 of who were released from custody during the project and did not complete. These learners were typical of the wider New Zealand prison population though it must be stated that different prisons necessarily focus on people with different security classifications and gender. There are no mixed gender prisons in New Zealand.

Participants wore an Oculus Rift CV1 VR headset and used an Oculus Touch controller in each hand. This hardware ran from an Acer Predator 15 gaming PC, which could be viewed by instructors while the learners were immersed. There were two VR set-ups in each classroom session. The VR activities were supplemented by activities on Samsung Galaxy tablets, as detailed later in this article.

## 3. The Lessons

The project began in April 2019 and ran for 10 weeks using virtual reality and tablet technologies. By the end of the pilot project, learners participated in at least 40 hours (and up to 100 hours) of virtual reality and tablet-mediated activities each. The virtual environment took the form of a mechanic's workshop equipped with detailed virtual replicas of cars such as a Ford Mustang and a Toyota Corolla. This scenario was chosen in consultation with learners during the design phase of the project as the men were interested in cars and were likely to promote engagement. The participants had to identify various car parts, tools, and features of the mechanic's workshop, manipulate the various components and respond to instructions. Before the lessons began, participants were given an induction where they were introduced to the technologies and were encouraged to use them until they felt comfortable. They were also shown how to look after the equipment so as not to damage it during use.




The activities in the VR were reinforced by game-based activities on Samsung tablets. Because there necessarily was not a large number of VR headsets due to their cost, the requirement for supervision, and a limitation on the amount of time, learners could stay engaged with the VR due to their comfort, some activities were designed for use outside of the VR. Activities included doodling with purpose, checking for understanding (where learners relate what they have learned), and mind mapping. These are generic classroom facilitation techniques recommended by speech-language therapists to support adult learners with speech-language communication needs (SLCN) (Dockrell, Lindsay & Ricketts, 2012). These techniques have previously been used individually and/or in an ad hoc fashion by prison tutors, and the intention with these lessons was to formalize their use and improve their application. The activities are explained in more detail below.

*Doodling with purpose* – tutors draw simple diagrams and illustrations (on paper or on a whiteboard) while explaining a concept or talking learners through activities for the day. This visual aid supports understanding for SLCN learners with difficulties with receptive communication. Doodling with purpose is a technique employed by speech-language therapists in New Zealand when working with youth and adults to provide simple visual aids to support oral communication – usually via simple hand-drawn doodles, diagrams, and sketches that the speaker will draw while speaking to reinforce or highlight important messages, ideas, or themes in their communication.

*Checking for understanding* – tutors simply asking open questions more frequently to check that learners are understanding communication and/or asking learners to relay their own understanding of a concept before moving on.

*Mind-mapping* – tutors and learners use post-it notes and simple whiteboard mind maps to recap content. This acts as another visual aid for communication.

The actual structure of the lessons was as follows: There were two-hour sessions with a 10-minute break in the middle. There was a maximum of 3 sessions per week. Each tutor worked with three or four learners. Each class used two VR units and two tablets.

Sessions were semi-structured with learners alternating between VR, tablet, and non-device activities (usually group-based). VR participation represented approximately 40 percent of the total learning time, tablet participation approximately 40 percent, and non-device activities approximately 20 percent.

Learners took part in two or three planned learning activities per session interspersed with self-directed learning activities (there was approximately a 50/50 split between structured and self-directed activities).

More specific activities included creating a parts catalog sequence and designing customer loyalty cards. VR activities included participating in a numeracy scavenger hunt, exploring an engine block, identifying hazards in the VR mechanic's workshop, and participating in an adding game. Learners could also learn practical tasks such as assembling and disassembling a brake caliper or fixing faulty brakes while receiving a mini-lesson and learning associated vocabulary. Participants were able to walk around the mechanic's workshop and even walk out of the workshop and onto the virtual street.

## 4. Data Collection and Results

Project instructors recorded their own observations and talked informally with participants throughout the pilot project, observing participants for engagement and learning. Learner progress was mapped using the LNAAT, and results recorded. A semi-structured formal interview of between 15 and 30 minutes was conducted at the end of the pilot project, which involved several questions about the ease of using the hardware, the activities, and their confidence in their literacy and numeracy skills. The following questions formed the basis of the interviews for all participants:

How did you feel about using the VR headset?

How did you feel about using the tablet?

What did you think about the learning activities?

What was good about this course?

What was not so good about this course?

How would you improve this course?

How do you feel about your literacy and numeracy compared to when you started this course?

Would you like to do more learning using VR?

Would you like to do more learning using tablets?

Would you like to do more work on your literacy and numeracy when you're released?

Any other comments or suggestions?

These interviews were recorded and transcribed. The data was analyzed using thematic analysis. Researchers closely examined the data to identify common themes – topics, ideas and patterns of meaning that came up repeatedly (Winter & McClelland, 1978).

As the number of participants was small, it was difficult to make generalizations about the results except to say that all learners made some gains. The LNAAT results indicated that all tested learners gained at least two steps in the LNAAT for numeracy and literacy. One learner gained three steps. These gains were made after participating in classes for between 40 and 100 hours. Each learner had different rates of participation due to competing demands on their time within the prison. There is a hierarchy of attendance at activities that is outside the control of both MMS and the participants. We hope to build on this data with further iterations of the project.

Participants quickly learned how to use both the VR and tablet technologies. Many expressed that even though the technologies were not what they were used to, it did not take long for them to get used to them. As one participant reported when asked how he felt about using the VR headset: *'Crazy at first! Had it all down by the first session though. Real easy once you know what you're doing.* And the tablet: '*Great. Easy to use and good to be able to pick your own activities. Enjoyed the videos and the games. Would like to see more!'*

It was noted that all learners were highly engaged with the pilot project. Learners reported feeling more motivated to attend and less likely to decline sessions. They were noticeably more engaged than in conventional intensive numeracy and literacy classroom delivery – with most learners actively engaged in activities for the full two hours of a session. This level of engagement was remarked on by the tutors who had typically delivered more conventional literacy and numeracy classes (without technology) previous to the VR sessions. Several learners requested to continue their VR learning when released (which MMS will facilitate in the nearby city of Dunedin via Community Corrections). All participants indicated strong enthusiasm for ongoing learning with both the virtual reality and accompanying tablets.

Participants rapidly progressed through step 1 and step 2 content and quickly developed confidence in the learning environment. Universally, participants felt that future learning content needed to be made more challenging. This indicated that the learners, assessed as being step 1 or step 2, readily mastered the content and gained self-confidence. This is reflected in the LNAAT assessments that indicated that all participants increased their step scores in literacy and/or numeracy. When asked how he felt about his numeracy and literacy skills, one learner reported: *'Real good. Have definitely brushed up on a few skills and learned some new ones. Mostly literacy though.'*

Neurodiverse learners reported enjoying the visual and audio prompts available in the VR and tablet exercises and felt confident trying new exercises in the headset and while wearing headphones. The immersive VR learning environment also appeared to allow for the introduction of phonemic awareness and number concept activities that are often difficult to introduce to adult learning environments. Learners enjoyed a range of prototype grapheme-phoneme activities delivered in a game-based way in VR, and ongoing development work is currently underway to further explore this opportunity. It appears there is strong potential to use VR to supplement the conventional 'whole language' approach to adult literacy and numeracy delivery with more targeted skill development for individual learners where appropriate. Neurodiverse learners with probable trauma histories reported feeling comfortable in the VR headset relative quickly (once they were aware of the classroom set-up and had established trust and comfort with other class members).

Instructors observed that all learners had made visible improvements in their ability to complete individual learning activities. The progress of the learners was viewed via system data.

It is likely that the combination of activities resulted in the gains in numeracy and literacy, but also the gains in engagement. The increased engagement was most likely facilitated by the use of VR as learners reported enjoying the VR activities. Even so, the use of the Samsung tablets also facilitated engagement, particularly as personal technology is uncommon in the prison environment. Increased engagement with the activities in the VR and on the tablets undoubtedly drove the significant gains in numeracy and literacy.

## 5. Some Unexpected Outcomes

The gains in literacy and numeracy achievement and learner engagement were expected. However, some other outcomes were unexpected. The virtual reality pilot at the Otago Corrections Facility has highlighted the huge potential in creating virtual scenarios where prisoners can also become educators. One participant of the pilot was sharing a cell with a person who was keen to participate in the pilot but failed to meet the eligibility criteria. The participant was working through a difficult engine assembly task and took very detailed step-by-step notes of what he was doing (up to a full page of A4 notes for each session) and drawing diagrams of key processes. He then took the notes back to his cellmate and revised them with him. He was clearly highly motivated to write and take notes for sharing knowledge. In doing so, he significantly improved his literacy skills as his work was more meaningful and memorable. By explaining the scenarios to his cellmate, he was also reinforcing his own learning.

Another participant requested that a multi-user virtual classroom environment be created, which could accommodate the avatars of other participants. He could foresee himself acting as an instructor and teaching the others what he had already learned.

Though we were not expecting those sorts of responses from the participants, they have alerted us to the great potential for personal development beyond the planned curriculum. These technologies allow us to create safe, predictable, realistic environments which can empower learners to become educators and sharers of information much earlier in their learning progress than would otherwise be possible in traditional classroom settings (where you need a high degree of tutor skill and extremely high levels of learner comfort with each other before most prison learners will even attempt this in a meaningful way).

## 6. Technical Performance

Overall, the equipment used for the pilot project operated well. Minor technical issues were experienced in the initial weeks (mostly due to the portable set-up of the VR sensors), and occasional ongoing interruptions caused by software updates and facilitator error, but was largely fit-for-purpose for single-site delivery. The current method of working offline and the manual loading and updating of content is sustainable for single-site delivery at OCF with MMS tutors, but not optimal for multiple site delivery at scale with third party providers.

The overall quality of the VR and tablet content continues to improve with ongoing learner input – including innovative ideas from neurodiverse learners on how to better utilize the immersive VR learning environment.

## 7. Scope for Further Research

Though the results of this pilot project were promising, there are several limitations to this study. First, this pilot project was run with a small number of participants on one site for a relatively short period of time. For these results to be generalizable, more learners at more sites would need to participate. Second, the participants of this pilot were not typical of learners outside of the carceral environment or even of all learners within that environment. For example, we are unable to say how

this project might play out in a women's prison, particularly given the subject focus of the VR program. Third, it is difficult to say if the results would be the same with a different focus, e.g. a carpentry workshop. Fourth, this project was unable to say which components of the program afforded the most significant gains in numeracy and literacy. Further research would help to address some of these issues. In addition, other areas would prove to be a suitable focus for further research.

Each prison in New Zealand has one or more Secure Online Learning (SOL) labs, each of which houses 8 or 10 thin client computers through which learners can access a handful of whitelisted websites (Department of Corrections, 2015). Files can also be made available to learners through this system. It would be beneficial if for future iterations of the project, a learning management system (LMS) could be loaded onto the SOL suites to enable us to more closely monitor learner progress through a series of activities within the LMS that would complement and augment the VR experiences with continuity for learners moving between prisons.

We are confident that the VR numeracy and literacy pilot has proven to be successful with learners in steps 1 and 2. Future iterations of the project would concentrate on those with higher levels of numeracy and literacy, specifically those at steps 3 and 4. More challenging learning content is now being added for existing tablet activities (including content for Step 3 through to Step 6 for most activities), and will be available to learners participating in a future iteration of the project that began in late August.

The mechanic's workshop was only the first of several environments that have been planned. Others include a forestry environment with diggers and forestry vehicles, virtual hairdressing and a virtual restaurant where participants could learn about being a chef (Otago Daily Times, 2018). It is hoped that future iterations of the project could accommodate larger numbers of learners for longer periods.

## 8. Conclusion

This paper reported on a pilot project delivering a low-level literacy and numeracy program contextualized in a virtual mechanic's workshop and delivered via virtual reality and tablets. It has demonstrated that these technologies are well-suited to this kind of delivery but also show enormous potential for use for vocational education and training. Using VR, prisoners engaged in vocational education could visit a virtual construction site or commercial kitchen (Zoukis, 2016). They could role-play a vocation such as being a mechanic or shop assistant and familiarize themselves with the environment in a way it would be otherwise impossible to do within a prison. Without leaving their cells, prisoners could learn safety and handling procedures such that when they leave prison, they are job-ready. This pilot project has demonstrated that the technologies can be made secure, minimizing risks of security breaches, and are more probably more secure than undertaking similar sorts of activities in the corresponding physical environments.

Importantly, these technologies were engaging to learners who generally have limited access to technology. While significantly improving their numeracy and literacy levels, they are importantly developing their digital literacies; something that most employers state as being crucial in the contemporary workplace (Herold, 2018). Most learners finished the program feeling more confident to participate in work and education inside and outside of the prison and are looking forward to continuing their learning journey. Low levels of literacy and numeracy have previously precluded these learners from participation in work or education. Now, these opportunities are available to them in line with their aspirations.

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