Building And Using Virtual Enterprises In Agricultural Education

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Abstract

Access to virtual food and fibre enterprises is a relatively new phenomenon in tertiary education. Historically, enterprise visits have mostly occurred by experiential learning on a farm or have been via limited use of images or video in the classroom. The development of mass marketed virtual reality head mounted displays has increased the popularity and availability of virtual reality in the last decade, although virtual tours may also be used on other displays. This paper provides a short background of Australian agricultural education and virtual reality followed by an overview of what is needed to produce a virtual food or fibre enterprise tour and three case studies of how tours can be used within teaching. These case studies include a use case for online learning modules, face to face case studies, online work-integrated learning, and as part of assessment following enterprise visits. Virtual reality has significant potential to improve student learning and maximise benefits of field visits, however further research is needed to define the benefits to staff and students when virtual tours are included in the curriculum.

Introduction

Agricultural education in Australia

Agricultural education has a long history in Australia with many of the current tertiary agricultural schools beginning in the late 1800s (Pratley, 2021). During an agriculture degree, students develop an understanding of a range of industries involved in food and fibre production. In most degrees a graduate is required to understand a broad range of production systems. Agricultural production systems across the world have significant differences in their environment and farm enterprise structures. The systems also change over time, including areas where agricultural graduates gain employment both on and off farm (Pearson & Ison, 1992). In an agriculture degree it is challenging to take students to more than a few enterprises due to pressures on time and budget when combined with issues such as availability during semester teaching time, biosecurity concerns and occupational health and safety that may all restrict the ability to visit enterprises. Extended trips also place particular demands on segments of the student population that may impact student diversity and inclusion for students with family caring roles, inability to access enterprises due to physical limitations or other needs.

While the demographics of students entering agricultural and animal science courses varies from course to course there has been a shift in urban versus rural students with increasing students from urban backgrounds. Over 67% of the Australian population lived in a capital city in 2021 (ABS, 2021). The past twenty years has also seen a significant change in the ratio of female to male students across many historically male dominated fields, including in agriculture (Pratley, 2021). This brings the demographics of the student population more in line with the average Australian population compared to the historical male dominance in agricultural students. One of the challenges in agricultural education has been reduced overall student enrolments in the early 2000s (McSweeney & Rayner, 2011), with numbers subsequently improving by the 2020s (Australian Government Department of Education, 2024). Another significant change to agricultural education over the last few decades, along with most tertiary education is a significant increase in technology use in most courses (Harper & Pratley, 2015). Not only is technology use increasing in the classroom but also on agricultural enterprises, increasing the need for gaining lifelong learning skills in agricultural technology (Cosby et al., 2023; Harper & Pratley, 2015). This change in technology integration has the potential to increase the interest in agriculture education and revitalise secondary student interest in the sector with a range of programs in this area (Cosby et al., 2019; Whannell & Tobias, 2015).

All of these changes around agricultural education provide both challenges and opportunities for the integration of technologies to aid the attainment of student learning outcomes. One key technology that may aid the student learning experience is on-farm "visits" via the use of virtual farm tours (VFTs). Use of these tours by students enhances their technology-based training, along with broadening their industry understanding. Presently, there are limited studies on benefits of VFTs within agricultural education, but some studies demonstrate benefits of virtual tours within the science, technology, engineering and maths fields (Zhaoet al., 2020).

Virtual Reality

The concept of viewing an image in virtual reality is not a new idea with early forms of virtual reality including panoramic room scale paintings and stereoscopic 3-D images, the precursors to the "Viewmaster" (Brown et al., 2017). The key goal for a virtual enterprise is to enable a person utilising the virtual tool to experience the reality of that enterprise. In most cases this is primarily a visual experience with or without an auditory experience. The more senses can be engaged in virtual reality experiences, the closer the experience may be to reality or to establish "presence" in the environment. The actual definition of virtual reality (VR) or virtual enterprises can vary significantly. Virtual reality is a subset of the broader class of extended reality (XR) which also includes augmented reality (AR). In contrast to VR which transports the user to a novel environment, AR brings novel material to overlay the real environment. For example, if you had AR and VR applications (apps) for tractor maintenance, the VR app would allow you to visualise a tractor with images collected previously and provide maintenance instructions. The AR app would guide you over the real tractor using your phone or headset to indicate maintenance instructions.

Following the earliest attempts of transporting viewers to new environments, early film used a range of techniques such as wide screen and 3D stereoscopic vision to immerse the viewer in the environment (Berkman, 2024). Jumping forward to the 1960s, the first head mounted displays (HMDs) were invented with perhaps the most well-known being called simply "the head-mounted display" although often referred to as "Sword of Damocles" due to its appearance (Sutherland, 1968). While a range of virtual reality devices were produced following these early HMDs, none reached a large consumer audience until the release of the Oculus Rift in 2013 for developers and the subsequent release of consumer versions in 2015.

This consumer-based device allowed a viewer to be virtually transported to worlds while wearing a relatively light HMD tethered to a computer with six-degrees of freedom (6-DoF) i.e. the user can move around the environment as well as viewing all directions. Other companies rapidly developed HMDs so that further options were available and more recently moved to non-tethered devices (Atsikpasi & Fokides, 2022). For lower input VR, a mobile phone may also be used as a HMD with a mobile phone inside a viewer. These have often been referred to as Google cardboard given the viewing case was often made from cardboard, allowing pricing to be relatively cheap. For this viewing modality there is less ability to interact with the environment as it is generally three-degrees of freedom (3-DoF) where the viewer is stationary, however this design has the advantage that it can also be used on a standard phone or computer screen.

Value proposition of virtual enterprises in education

Much of the drive for production of virtual reality content arises from the gaming industry. There are, however, significant benefits to integrating virtual reality use in education, including ease of access where enterprises have concerns around occupational health and safety or biosecurity, improved timing of access, reduced transport time for enterprise visits, potential cost savings, accessibility for some learners, and the ability for reflection and preparation. Another reason can be for achieving learning outcomes around utilising and integrating technology. As a part of universal design for learning (UDL) framework, a virtual environment can assist learners by providing multiple ways of engaging with content, consistent with Principle 3 of UDL (engagement) when used alongside other learning resources (Capp, 2017). As more learning content is moved to predominantly on-line access, the design and delivery of this is important to consider for the learning needs of both current and future student cohorts.

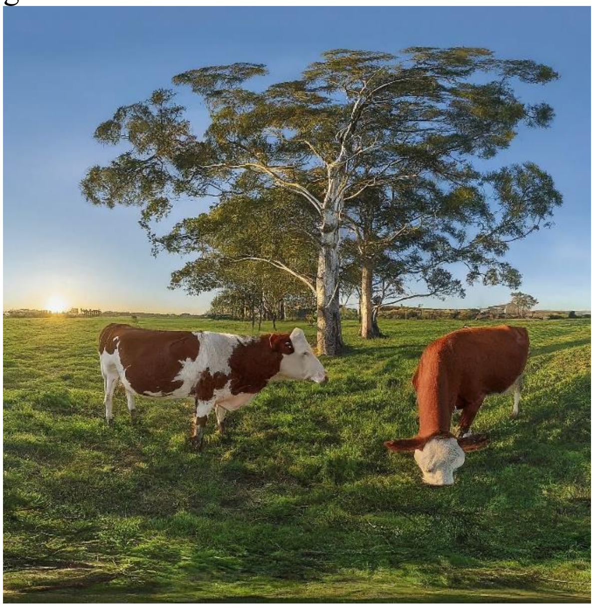
Once a virtual tour has been produced, the cost of deployment or delivery to students depends on the design and annual costs for maintenance. A single virtual tour can potentially be used across multiple subjects and courses, depending on how it is designed. This can be an important step in initial tour design to ensure maximum use, spreading the costs of development over a wider pool of subjects and students. A key decision around the development of virtual reality content is what format the tour will take; potentially 360-images at a single time point, linked 360-images through time, 360-videos or computer-generated content that must be produced either from existing visuals or written material. This may impact how the material can be shared and whether it is solely suitable for HMD or if it can be utilised across multiple viewing options i.e. HMD, mobile device or computer screen. While there are limited examples of virtual reality and VFTs dedicated to agricultural education, a significant number of tours have been produced in the past ten years by government, rural research and development corporations and other groups (see Appendix 1 for some examples). The majority of these tours are 360-video oriented with the ability to move between multiple scenes at the farm or across farms.

A key short-term challenge is that while there has been some production of VFTs in agricultural education, published research on student outcomes is lagging. Case studies, such as those presented in this paper, provide early demonstrations of potential benefit. In other STEM areas there has been variable feedback on the use of virtual tours, potentially in part due to variation in design of the tours (Cromley et al., 2023).

Building a virtual farm

Before commencing building a VFT it is important to consider the expected or desired learning outcomes from users interacting with the virtual environment. This will impact the type of virtual experience that is needed and where these images should be collected or generated. Similarly, decisions need to be made about the method of final delivery of the content and what hardware learners will have access to for accessing the content. Where the collection of information involves a team of people, methods of communication and project design are also important to define and enable iterative change to occur as needed for project delivery. For example, in building the virtual reality enterprises, 4DVirtualFarm and DookieVR, 360-degree images were captured by camera on the enterprise and repeated over multiple time points to allow users to both move across the enterprise and through time (Hallein et al., 2024). Advances in generative artificial intelligence may soon be feasible to produce images like those collected on-farm. Figure 1 shows a basic prompt using Google Gemini to produce an image of an Australian farm. While a number of issues appear in the images, the overall picture conveys the intent behind the prompt. There are, however, a range of potential outputs and a risk that missing details may impact the expected learning outcomes as noted by Klug & Pietsch (2024).

Prompt: Please draw an equirectangular image suitable for 360-degree display. In the image place some red and white cows, green grass and a background showing Australian gum trees.



Prompt: Please draw an equirectangular image suitable for 360-degree display. In the image place some red and white cows, dry summer grass and a background showing Australian gum trees.

Figure 1: Output from Google Gemini in June 2024 from text prompts to produce images.

A range of options exist for using computers to generate virtual reality content either producing static or moving images in three dimensions. This has significant application in training-based scenarios. An example of this is introducing a user to identifying the signs of Foot and Mouth Disease which is an exotic disease to Australia, which the user is able to "experience" without travelling to a different country (Wilson & Wilson, 2020). A range of animal handling scenarios have also been developed using VR, including performing procedures on laboratory animals (Tang et al., 2021). To build a picture of an extensive farm requires the viewer to be able to view a number of different areas of the farm. In addition to this, it is often useful to add in further information, both with access to farm data and video content. This video content may either be 360-video or standard two-dimensional video. The following sections review the requirements for producing this type of virtual tour of a farming enterprise.

Hardware requirements

Learning outcomes decided prior to commencing image acquisition to develop the VFT will enable decisions to be made on what kinds of hardware may be needed. There are a few categories of equipment that should be investigated

- 360-degree photography
- 360-degree videography
- 360-degree sound
- Standard photographs, video, and sound.

360-degree photographs

Over the past 15 years there has been consistent and significant change in the availability of equipment for collecting 360-degree photographs on agriculture enterprises. The first method of collecting 360-degree images is using a camera such as a digital single lens reflex (DSLR) camera with a fisheye lens. This is placed on a tripod and using a mounting bracket it is rotated around 360-degrees to collect images to complete the 360-degree view. For use in a farm environment, it is important that the tripod is very stable and can be adjusted to keep the camera level. It may also need to be weighed down to avoid the potential of damage due to environmental conditions such as wind or interaction with livestock. Depending on the camera and lens combination, multiple rows of images along with bottom (nadir) and top (zenith) images may need to be collected. If a high dynamic range image (HDR) is desired to show features in bright and dark areas of the image, multiple exposures of the same image may need to be collected.

Over the past ten years, a large range of 360-degree cameras with two or more lenses have become available to collect a full 360-degree by 180-degree image. These cameras vary from consumer to prosumer and professional levels with associated cost. The significant advantage of most of these cameras over a DSLR is that the entire 360-degree image is collected at the same time, avoiding issues of movement such as animals moving while the camera rotates. This can significantly reduce the time required in post-production editing. The disadvantage is that generally these cameras produce a lower quality image. Some 360-degree cameras only take photographs, such as the Panono (https://www.panono.com/), Trisio (https://www.trisio.com/) and Xphase Pro (https://www.stabilizer-pro.com/xphase-pro-360-p0159.html), while other 360-degree cameras will take both photographs and 360-degree video. Cameras also have a varying number of lenses, the most common number being two lenses at opposite sides of the camera body. The Trisio and Xphase Scan use a single lens, but the body rotates while the Panono and Xphase Pro use 36 and 25 lenses respectively. Different cameras also come in different form factors and sizes that may make them better suited for varying types of image collection. There are regular changes and updates in this area of technology so new cameras can become obsolete in a relatively short period of time. A tripod or similar device that is solid enough to hold the camera still and small enough to minimise its visibility in the image is an important piece of equipment.

Most 360-degree cameras have their own software systems for image collection and processing with moderate variation in how simple these are to use. There is also a significant range in the image quality each camera can produce, which may be an important consideration in which camera to use. Additional parameters to consider are the weight of camera and tripod and how this will be transported around an enterprise as well as methods to protect the camera in transit. All dual lens 360-degree cameras are inherently easy to damage as the lenses protrude from the body of the camera.

360-degree video

As already noted in the previous section a range of cameras can take both 360-degree photographs and video. Some common brands that do both photo and video include Insta360 (https://www.insta360.com/), Kandao (https://www.kandaovr.com/), PanoX (https://store.panox.com/), Ricoh Theta (https://www.ricoh360.com/theta/) and GoPro (https://gopro.com). There are a broad range of cameras at varying price points with more expensive cameras generally having a greater number of larger sensors. For example, the Insta360 Titan professional camera has eight micro four thirds inch sensors compared to the

Prosumer Insta360 X4 which has two half inch sensors. This results in significant differences in video output quality and size. This also has implications for the computer processing power needed to process these videos. When using 360 cameras for photography or video it is important to be aware of how close you can get to the camera before artifacts will appear due to the line where the multiple lenses will be stitched together. Different cameras will have varying distances in which artifacts will occur and the camera should be placed at least that far away from likely filming areas. Additionally, the camera should be placed at an appropriate height of an average person and in a position that a person might stand or sit as that is the view that someone will have in VR.

360-degree sound

While often not considered as much as image, sound is an important part of the immersive experience in virtual reality (de Villiers Bosman et al., 2024). A range of 360-degree sound recording devices are available and most 360-degree video devices record 360-degree sound, although it may not be adequate quality depending on what audio requirements need to be met. Ideally any sound recording device can be fixed to a 360-camera and fit in the "blind spot" of the camera to avoid it having to be removed in post-production from the video. Audio may be an important consideration within subject learning outcomes, at least as part of generic learning outcomes.

Equipment to capture standard photographs, video and sound

In addition to 360-degree images and sound, it is often useful to record a range of other material that may be added to the final VFT to illustrate certain learning outcomes. This can include standard two-dimensional video recordings, audio recordings or data collection for display. Equipment required for these areas will vary depending on what the requirements are for the final product, so are not covered in detail here. A moderate quality phone camera with an attached lavalier microphone can often produce acceptable quality video for many teaching needs in a cost constrained environment.

Processing images

Once a 360-degree image is collected it must first be stitched into a single image from its constituent parts which is a minimum of at least two images from a dual lens 360 camera and may be up to 36 individual images, depending on camera design. In addition, for a high dynamic range (HDR) image this may require at least an extra image above and below (or 3 brackets) the expected exposure value (EV). These images may be composed of 3 brackets, 5 brackets or more of the images. Alternatively, a digital negative (DNG) image may be collected which contains more image data than a JPEG image, if the camera supports DNG format. For most 360 cameras the images that are produced can be stitched on their proprietary software to produce an equirectangular image that is twice as wide as it is tall. Processing images from a DSLR requires software such as PTGui (https://ptgui.com/) or Hugin (https://hugin.sourceforge.io/) to stitch photos together to create this image. Once an equirectangular image is created the next step is to choose an image display method that allows the user to interact with it and to move across the multiple images on the enterprise.

Displaying images

There are a range of decision points for deciding on the optimal image display software and where images will be physically located to allow this display. This will also depend on the complexity of the model chosen to display images. For example, are images to be collected through time at the same GPS point? This will increase complexity of the display method. Additionally, learning objectives may require the addition of other information to a VFT site such as temperature and rainfall, production indices or other management factors. In addition to this you may wish to add a range of 'hotspots" to include extra photographs, video, or other file types to the tour. A range of tour options exist with variations in how they support these options. Some of these include krpano (krpano.com), 3DVista (3dvista.com), Kuula (kuula.co), CloudPano (cloudpano.com), Virtual Tours Creator (virtualtourscreator.com.au), Matterport (matterport.com) and others. Additionally, there are a range of potential output types to various devices that are supported. Different systems vary with the complexity required to utilise them to their maximum capability and the degree of coding that may be needed versus 'plug-and-play' for less experienced users. An overview of the methods chosen to produce the 4DVirtualFarm is available (Hallein et al., 2024).

Virtual reality case studies

Once a virtual tour is developed it can be used with students for learning. This can be an important process in the learning design for iterative improvement if feedback can be captured on any issues that are encountered from users. Within the production animal curriculum at the Melbourne Veterinary School and School of Agriculture, Food and Ecosystem Sciences within the Faculty of Science, VFTs including 4DVirtualFarms and DookieVR are used in a range of different areas. The following three case studies illustrate some examples where the VFTs are used in student teaching in various formats, either face-to-face or on-line.

Case study 1: Integration of VR into first year animal production learning and teaching curriculum

A. Integration into subject theory material.

Both DookieVR and the 4DVirtualFarms are integrated into teaching two production animal subjects within the first year of the Doctor of Veterinary Medicine at the University of Melbourne. Since 2020, these subjects have moved to all theory material being presented on-line via a learning management system (LMS), primarily using relatively short video presentations of less than 10 minutes. In addition to this there is a range of supporting written material along with a range of links, including use of VFTs.

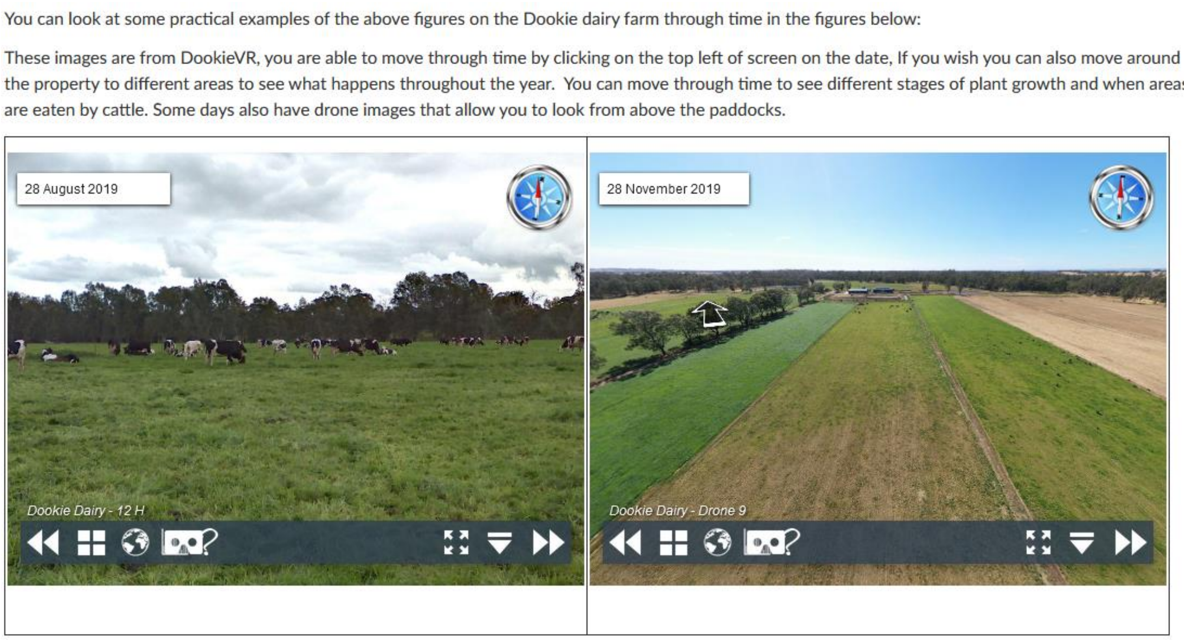


Figure 2: A screenshot from a first-year extensive animal production subject Learning Management System illustrating the use of DookieVR, showing part of multiple 360-degree images.

Figure 2 shows a comparison of ground-based and drone views of the Dookie dairy enterprise. The starting view and time shown for the viewer can be chosen by the subject designer/co-ordinator. Students then have flexibility in how they review content, both across the enterprise and through time. The user can also review the temperature and rainfall associated with visit dates. In addition to being able to view an individual farm, students can access a range of enterprises to compare and contrast production systems in different areas. For example, comparing a beef enterprise in Victoria and one in Queensland approximately 1,600 kilometres apart in Figure 3. This allows students to place farm management procedures both in place and time including seasonal conditions.

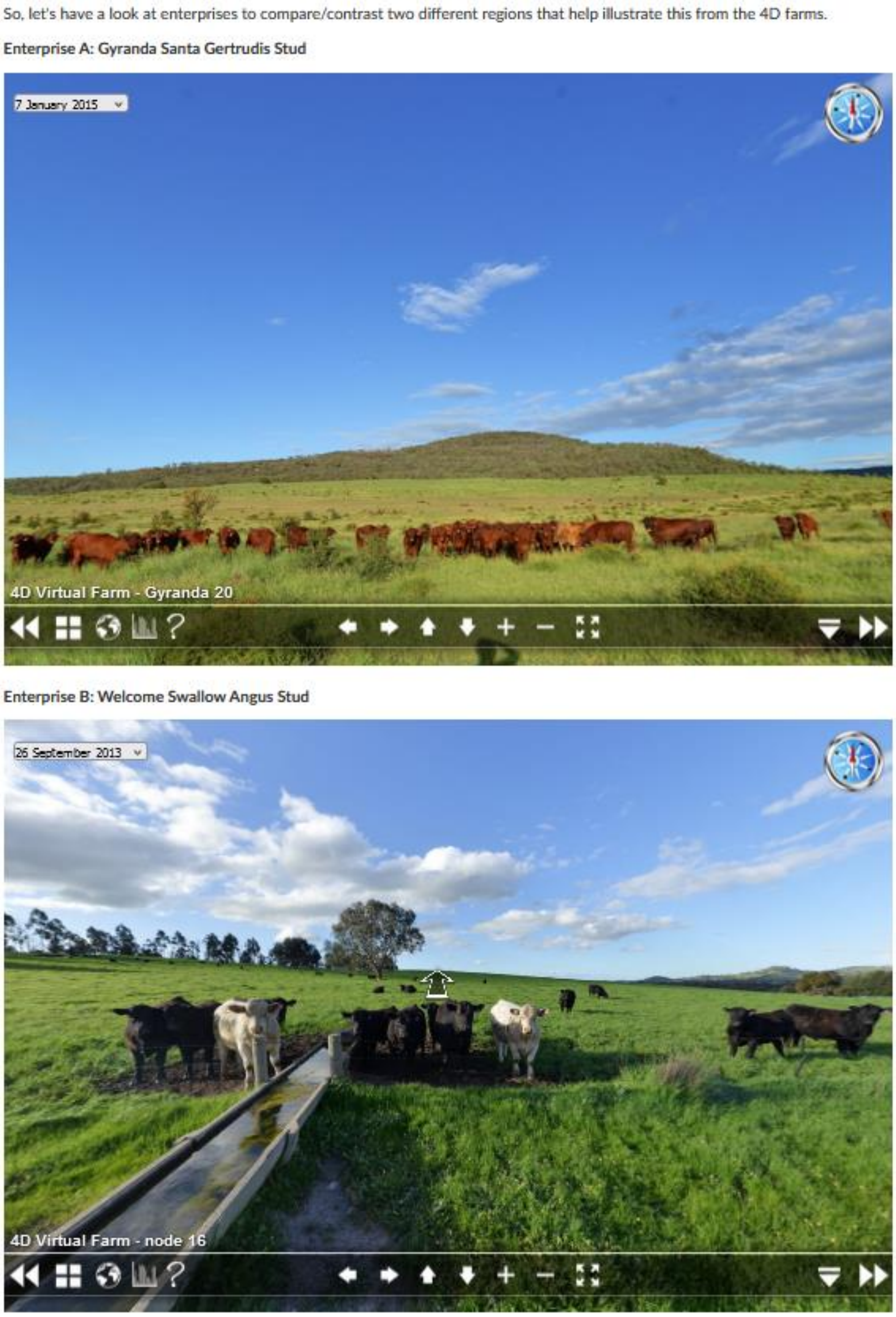


Figure 3: A screenshot from a first-year extensive animal production subject Learning Management System illustrating the use of the 4DVirtualFarm showing a comparison between two beef enterprises.

B. Utilisation in live case studies

In addition to using the virtual farm in theory content it is also used in face-to-face case studies. Case studies for these subjects consist of 3-hour sessions in a small group case study format as described by Barber (2022). The virtual farm enterprises are commonly used to illustrate principles prior to student groups working on problem-based scenarios. Use of the VFTs in these case studies is both explicit and implicit. Students are shown how to use them in the first case study and the VFTs are used by teaching staff as background for other case studies throughout semester. Students also spend a week at The University of Melbourne's Dookie campus in northern Victoria and are able to review DookieVR both prior and after the week on farm. This allows them to prepare for what the farm looks like before they arrive and also to reflect once they return.

Case study 2: Use of VR in work integrated learning

Work integrated learning (WIL) is an increasing component of a range of courses including agriculture and veterinary science. It is an important element of understanding how individual enterprises function as compared to theoretical enterprises or industry averages commonly described in university courses. Ordinarily, students completing WIL in veterinary science courses in Australasia have to complete 12 weeks of work on a range of animal enterprises with a focus on both extensive and intensive agriculture.

During COVID lockdowns it wasn't possible for students to visit farms. Hence, an online WIL week with up to 250 students from 6 universities in both veterinary and agriculture science was commenced (Barber & Brown, 2021). The key benefit of the virtual enterprises was being able to provide a continuation or commencement of placements despite lockdowns being in place. Both 4DVirtualFarms and DookieVR were used to provide virtual access to a prime lamb enterprise and a robotic milking dairy enterprise in Victoria. A range of other online learning technologies were used in addition to the enterprises to illustrate different processes on each enterprise. It was very useful to have images through time from each enterprise to allow discussion around the changes throughout the year.

Some positive feedback from students included the following:

> *"I really hope the virtual EMS continues for further cohorts since depth I got about the enterprise and industry were very interesting and I doubt I would be able to learn everything I have even on a physical place",*

> *"It was great to learn and get an understanding of dairy cattle and the industry in an environment with no pressure where I felt comfortable to ask questions to further my knowledge which will assist me when I complete on-farm placements."*

> *"Seeing the current technology in practise (lely system, 360 video, 4d farm) and how this can shape the future of animal industries. Also the 6 questions videos."*

An example of how the VFTs were used during the week was that, on the first day of the virtual visit, each student group had to produce a report on the enterprise, reviewing the major environmental health and safety risks for the enterprise. This report required the students to capture a screenshot of the enterprise, identify the risks, and provide relevant external references detailing further information about the risks and how they could be managed or eliminated. Student groups then submitted this task via Feedback Fruits with feedback from student peers the next day (see Figure 4).

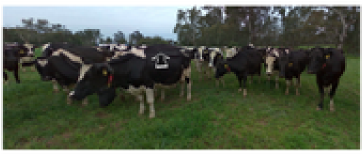
	• Animal related injuries • animal handling and husbandry, bites, kicks, crushing, ramming, trampling, and transmission of certain infectious (zoonotic) diseases	• Training in animal handling • Knowledge of animal behaviour • Emergency plan • First aid training • vaccinations

Figure 4: An example of a section from a student report incorporating a screenshot from DookieVR demonstrating discussion from the virtual enterprise.

Case study 3: Agriculture field trip assessment

In the first year of the Bachelor of Agriculture degree, one of the core subjects taught is Animal Production Systems. This subject spans a semester and incorporates a 2.5 day field-trip to The University of Melbourne's Dookie campus in late winter/early spring. During the field trip the students undertake several activities that involve collecting data related to various aspects of the farm's operations. These include data on pasture growth at the Dookie dairy as well as collecting dairy production information. These activities provide the students with practical on-farm experience in data collection. Subsequently, the students are required to produce a report on the Dookie farm where they incorporate data that they have collected. As part of their Dookie assignment, students are also asked to review rainfall data from Dookie spanning a number of years and to incorporate these with the 360-degree images collected at Dookie over the same time period. The students are able to use the 360-degree images to view the farm over time and gain a better understanding of how rainfall and season impacts pasture growth during the year and between different years. The use of the 360-degree farms provides a unique experience for the students by bringing together historical data with recently collected information. The teaching of this subject is greatly enhanced by the use of the 360-degree farm information, which adds significantly to the learning experience of students who would ordinarily only get to see a very narrow snapshot of the Dookie farm at a particular point in time.

Discussion

This article provides a small subset of the potential uses of VR within VFTs. As expectations around use of technology increase in food and fibre production systems, it is likely there will be increased expectations by the agriculture sector for universities to provide increased access to technologies such as VR and extended reality. The case studies presented here are recently developed subjects to allow interaction with VR directly through an LMS. Alternatively, the VR could be used in a standalone manner using HMD, mobile devices, or desktop computers. In addition to being used to introduce students to a range of principles in the classroom, virtual tours may also be used for assessment, most commonly online. This allows authentic interaction with a virtual farming enterprise to respond to real world questions. Additionally, a virtual farm can be used to aid reflection about enterprise visits and to provide background to data collected from on-farm visits as detailed in case study 3. Further, case study 2 demonstrated the ability of the virtual farm to be used by large groups of students from different universities across an entirely new virtual curriculum for a week during COVID lockdowns. A key part of VR design for broad scale use is how simple it is to use and how flexible it is to integrate into a range of educational needs (Hallein et al., 2024).

The cost of producing VR content initially can be relatively high compared to traditional teaching, depending on what kind of content is produced, however there is the potential to share these costs across a wide group of users. Food and fibre VR content has potential applications across the entire education sector from primary to tertiary levels as well as in commercial settings. This may however require different use of the virtual enterprise and potentially different display methods. One challenge with the use of VR in HMD is that a percentage of the population may encounter VR sickness (Chang et al., 2020). A benefit of designing VR for use across multiple devices such as HMD, mobile phone or desktop viewing is that it allows any user experiencing sickness to use a different option. While up to 250 users interacted with the virtual environments using DookieVR in case study 2, this was as individual users. Although there is no current ability to have peer to peer discussion within the actual VR environment, this was achieved with concurrent use of Zoom. Other examples of VR do, however, allow peer to peer interaction within a 6-DoF VR environment (Parikh et al., 2022).

While VR originated more than 50 years ago, it has not been used broadly in education until the last ten to fifteen years. Reports of the use of virtual reality and virtual tours in the current agricultural education curriculum are infrequent (Oliveira & Corrêa, 2020). They are, however, increasingly being developed by government and research and development corporations to provide a view of how agricultural enterprises function (see Appendix 1) and are used in tertiary education. Much of the reporting of VR projects also tends to be in online commercial or conference literature, rather than peer reviewed journals. A challenge for using virtual tours or virtual reality in education is defining the student or overall benefit of the use of the technology, apart from developing technological literacy as a generic learning outcome. This can represent a challenge to develop the case for funding. Prior to the development of a novel VR environment, it can be difficult to forecast its use and ability to meet expected outcomes. Increasing numbers of virtual tours, however, allows for some iteration with testing prior to funding VR development. More research outputs from the development and the use of VR and VFTs is required to add to its potential benefits in agricultural education.

Conclusion

The use of VR is increasing in education with the costs and technical challenges of VR production reducing and expectations of staff and students around the use of technology in education increasing. Overall use of VR in agricultural education is currently at a relatively low level but there are significant potential benefits for using it when applied to appropriate learning outcomes. To reduce cost per student, collaborative development programs of VR enterprises have appeal, in addition to accessing optimal educator expertise. Further published work is needed to demonstrate positive student outcomes from VR use, along with positive student feedback.

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Appendix 1: Other examples of virtual reality or virtual tours in Australian agriculture and education:

Organisation	Location of VR experience
Australian Pork	https://australianpork.com.au/virtual-tour
Australian Eggs	https://www.australianeggs.org.au/farming/tour
Meat and Livestock Australia	https://www.goodmeat.com.au/educational-resources/digital-lessons
MLA – lamb 360	https://www.youtube.com/watch?v=g_UBlxbA8Ls
MLA – beef 360	https://www.youtube.com/watch?v=HPvFQZx8HYQ
Dairy Australia	https://www.dairy.edu.au/virtual-reality
Primary Industry Education Foundation Australia (PIEFA)	https://virtualfarm.melbournefoodbowl.com.au/home.html
PIEFA Farm VR farm safety	https://farmvr.com/virtual-tours/piefa/farm-safety-1
Tocal Farm	https://storymaps.arcgis.com/stories/59e8f8a1f6c24bb79d343c43bad36a76
Boomaroo nursery	https://agco360.uqcloud.net/#/site
Think Digital	https://farmvr.com/experiences/
Agriculture Victoria	https://extensionaus.com.au/energysmartfarming/wilandra-farm-virtual-tour/
Australian Lot Feeders Association	https://app.cloudpano.com/tours/BC1xTEZxI
University of Queensland	https://study.uq.edu.au/university-life/campus-tours/virtual-tours
The Livestock collective	https://www.thelivestockcollective.com.au/vrshiptour
Belgenny Farm	https://3dinsights.com.au/viewer/belgenny_farm/creamery/