Development of 4D farms to improve student learning and safety

Final report 2016

The University of Melbourne

Massey University, Murdoch University, The University of Queensland, The University of Sydney

Dr Stuart Barber (lead) (The University of Melbourne)

Mr Evan Hallein (The University of Melbourne)

Professor David Shallcross (The University of Melbourne)

Dr Jenny Weston (Massey University)

Dr Caroline Jacobson (Murdoch University)

Dr Elizabeth Bramley (Murdoch University)

Dr Pietro Celi (The University of Sydney)

Dr Michael McGowan (The University of Queensland)
Support for the production of this report has been provided by the Australian Government Office for Learning and Teaching. The views expressed in this report do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

With the exception of the Commonwealth Coat of Arms, and where otherwise noted, all material presented in this document is provided under Creative Commons Attribution-ShareAlike 4.0 International License http://creativecommons.org/licenses/by-sa/4.0/.

The details of the relevant licence conditions are available on the Creative Commons website (accessible using the links provided) as is the full legal code for the Creative Commons Attribution-ShareAlike 4.0 International License http://creativecommons.org/licenses/by-sa/4.0/legalcode.

Requests and inquiries concerning these rights should be addressed to:
Learning and Teaching Support Unit
Student Information and Learning Branch
Higher Education Group
Department of Education and Training

GPO Box 9880
Location code C50MA7
CANBERRA ACT 2601

<learningandteaching@education.gov.au>

2016

ISBN 978-1-76028-809-9 [PDF]
Acknowledgements

We would like to acknowledge the assistance of the property owners and managers in allowing us to collect images and video from their properties for display within the 4D farms. Without their assistance this project would not have been possible. We would also like to acknowledge the assistance of our project reviewers Dr Chi Baik and Professor Colin Wilks, reviews from Dr Bruce Allworth and Dr Kym Abbott, support and feedback from a large number of agricultural and veterinary students and scientists from around Australasia which aided improvement of this resource. Finally we would like to acknowledge the support of our families and friends who kept households running while we were on-farm collecting images for the project.
List of acronyms used

4K – Resolution of approximately 4,000 pixels horizontally on a screen
4D – Four Dimension (4th dimension = time)
AR – Augmented Reality
AT – Assessment Task
EHS (OHS) – Environmental health and safety
GPS – Global Positioning System
ILO – Intended Learning Outcome
LMS – Learning Management System
MB - megabyte
POV – Point Of View
TLA – Teaching and Learning Activity
UAV – Unmanned aerial vehicle
UI – User Interface
VR – Virtual Reality
Executive summary

The 4D farms site is the first agricultural and veterinary science learning and teaching site of its kind in the world using multiple 360 degree images through time to illustrate animal production systems. It allows students to visualise what happens on properties throughout the year in different parts of Australasia separated by more than 5,000km east to west and 3,000km north to south. These properties cover a wide range of animal enterprises including wool sheep, meat sheep, dairy cattle, beef cattle and pigs. They range in climate from Mediterranean to temperate and tropical climates, producing very different amounts of fodder at different times of the year. It is highly unlikely that any individual student would have the financial ability or the time to visit all of these properties throughout their degree for an individual visit. Even less likely that students would be able to visit multiple times to view what happens in different seasons.

The basic 4D farms site allows the viewer access to over 17,000 35MB photos catalogued in a visually appealing and easy to navigate storage system. Further multimedia files and Microsoft office product files are available via a glossary so that users can see explanations over the 4D farm. This glossary is contained in an editable PHP database that can be updated as glossary terms change or teaching staff recognise terms that students find difficult to understand. The editing tool for this database is very user friendly as hotspots can be added to the glossary with a click and then text added to the database with minimal information technology experience required. A further editing tool has been produced that allows the user to direct someone to a particular property, on a particular date, at a particular position on the property, facing a particular way at a set zoom level. This allows a teacher or a student to show someone else an exact location on a property to illustrate a particular point. The tool can therefore be used in directing students to answer questions about particular intended learning outcomes for the site, or equally, students could use this tool to answer particular questions to demonstrate they have been able to find a certain item. A further key point about the design of the site is that it will function across any system, including Apple or PC desktop/laptop or iphone/ipad/android operating systems to allow any user to access the site. Some previous 360 degree viewing platforms were only available on apple or PC making the 4D farms site far more accessible and flexible in delivery.

The current 4D farms site has received highly positive feedback at a number of national and international conferences with veterinary and agricultural science teaching staff. It has also received very positive feedback from students when used in lectures and case studies, but due to the time taken for development of the site it is yet to be fully integrated into any teaching subjects. Student evaluation of the site will occur across a number of universities in 2016. Students will be able to access the site at University prior to visiting farms, on-site (where they have adequate internet or wi-fi access) and then on return to universities.

Development of 4D farms to improve student learning and safety
Lecturing staff are able to use the site in most standard platforms, such as Learning Management Systems (LMS), for teaching and learning exercises or for assessment tasks. The site can be inserted into most learning management systems or alternatively used direct via the website. This allows teaching staff flexibility in how they introduce students to the site and how their students use it.

The development of the 4D farms has required a great deal of collaboration between farmers, veterinarians at each University and the project team as well as significant feedback from a range of other staff. One area that could add to the 4D farms is further internationalisation of the site given the number of Australasian veterinarians that work internationally. In addition there are a number of new technologies that will become available over the next few years. The use of virtual reality devices such as Oculus Rift has significant potential to enhance the user experience of the 4D farms site. Augmented reality for taking the lecture theatre to properties also has potential for changing self-guided learning, particularly on university properties with repeat student visits. The ability to further enhance the images used in the 4D farms using timelapse or different views, such as those from drones (unmanned aerial vehicles or UAVs) also has the potential to improve student understanding of intended learning outcomes. While this program has been very successful, it does demonstrate that there are significant areas for further research and development to add to the 4D farms once data analysis of student feedback on this project is complete. It would also be useful to follow the “paddock to plate” nature of food production to aid students understanding of the full production of where food comes from and what is involved in this process.
Table of contents

Tables and figures ...................................................................................................................... 9
  Tables ..................................................................................................................................... 9
  Figures ................................................................................................................................. 9

Chapter 1: Background to the project ..................................................................................... 10

Chapter 2: Planned project outcomes ..................................................................................... 11

Chapter 3: Methods used & outcomes.................................................................................... 14
  Produce an authentic reproduction of real life scenarios on farms across Australasia... 14
  Develop a minimum of ten virtual farms with a mix of different enterprises .......... 18
  Allowing self – paced learning, development of a glossary .............................................. 20
  Seasonal change – integration of rainfall/temperature ................................................... 21

Chapter 4: Key factors in project outcomes ............................................................................ 23

Chapter 5: Deployment and use .............................................................................................. 24

Chapter 6: Project publications and recognition ..................................................................... 26
  Journal publications .......................................................................................................... 26
  Conference presentations ................................................................................................ 26
  Seminar presentations ...................................................................................................... 27
  Submitted for review ........................................................................................................ 27
  Press articles ..................................................................................................................... 27
  Social media ...................................................................................................................... 27

Chapter 7: Future.................................................................................................................... 28

References or bibliography ...................................................................................................... 33

Appendix A ............................................................................................................................... 34

Appendix 1: Basic User Instructions ........................................................................................ 35

Appendix 2: .............................................................................................................................. 37

Initial meeting of OLT Review Committee for “Development of 4D farms to improve student learning and safety” .................................................................................................................. 37
Appendix 3: ..............................................................................................................................40
Title: Final meeting of OLT Review Committee for “Development of 4D farms to improve student learning and safety”. .....................................................................................................................40
Appendix 4: Some suggested ideas for integration of the 4D farms site into teaching........42
Tables and figures

Tables

Table 1: Property types and locations of 4D farms ................................................................. 15
Table 2: ILO’s ............................................................................................................................ 15

Figures

Figure 1 A view of a dairy farm at Caldermeade using Google street view (modified) .......... 11
Figure 2 An example of a 4D diary farm environment (yellow highlight boxes demonstrate some features for users) .............................................................................................................. 12
Figure 3 Seven images required for each “node”: 60 degree increment horizontal and one directly up. ........................................................................................................................................ 16
Figure 4: Seven images stitched into single image to allow full 360 degree view ............... 16
Figure 5: Two screen shots of the 4D farm interface, comparing changes at different times of year. January 2013 (left) and August 2013 (right). Differences in pasture quality and growth are easily identified ................................................................................................................. 17
Figure 6: Illustration of the key feature of the 4D farms site .............................................. 17
Figure 7: Screenshot of the front web page of the 4D farm site ........................................... 18
Figure 8: The four seasons at a sheep property in NE Victoria shown in the 4D farm ......... 19
Figure 9: Range of properties – differences in topography, climate, grass types, cropping and other variables ............................................................................................................................... 19
Figure 10a: Development of a visual glossary................................................................. 21
Figure 10b: Interaction between glossary & 4D farm........................................................... 21
Figure 10c: Insertion of audiovisual or Microsoft office files into 4D farm eg. video ......... 21
Figure 11: Demonstration of seasonal change in different environments – WA on top row, NZ on bottom .......................................................... 22
Figure 12: Using the 4D farm inside the University Learning Management System for assessment ................................................................................................................................. 25
Figure 13: 6 GoPro 3 + cameras mounted on a 360 Heros system for recording 360 degree video ................................................................................................................................. 28
Figure 14: Aerial view of sheep yards in Tasmania showing stock movement using GoPro cameras (thanks to @DroneAg for flying our cameras) ............................................................... 30
Chapter 1: Background to the project

One of the biggest challenges in agricultural and veterinary education is transporting students and staff from the place of education to rural enterprises. This costs significant time and money and thus limits the range of properties that can be visited. There has also been a shift in the demographics of students undertaking veterinary and agricultural degrees around the western world in the past 20-30 years. The major shift has been a reduction in the number of students undertaking the degree from a rural background and also a reduced ratio of male to female veterinary students. This means that not only is it more challenging to get students onto rural properties, but they also tend to have less experience in agriculture prior to commencing their degree. This point is clearly illustrated in Australian demographic trends with the vast majority of the Australian population now residing within cities and far fewer people in rural areas and towns compared to twenty years ago.1

Some universities located in rural areas recruit students based in-part on a history of working with animals and particularly livestock. While this can give an increased experience within this general locality, it is unlikely to improve students’ ability to visit production systems from other geographic areas. Veterinary graduates from Australian universities are able to work across the world so an understanding of different animal production systems is important to allow them to provide the best advice on animal health in different areas. This knowledge is hard to gain, given differences over time and geography between different systems.

The 4D farms site was developed to provide an environment for veterinary or agricultural science teaching across a range of farming systems. This information allows agricultural and veterinary science students to visualise what happens on farms throughout the year prior to visiting properties, aids their understanding during visits and then on return to the University. Previous research showed that students believed this sort of site would be beneficial to further their learning, as has been shown in other disciplines. Collaboration between a number of engineering faculties funded by the ALTC led to the development of a forerunner to this technology, which allowed a representation of the development of a chemical engineering plant over time. The 4D farms site is the first that allows the viewer to see a number of different areas on multiple properties in 360 degrees and how these change through time in rural enterprises. The goal of this program was to produce material that would significantly aid students ability to understand how different types of farms function, how they change throughout the year and to be able to explain and expand on a number of key learning outcomes.
Chapter 2: Planned project outcomes

At the commencement of this project the planned project outcomes were:

1. Production of an authentic reproduction of real life scenarios on farms across Australasia in diverse geographical locations and during different seasons for students to view in the classroom. The rich visual images that are produced are similar to that provided by Google street view in metropolitan areas, however the four dimensional (4D) farm will allow the viewer to visualise the overall farm layout with appropriate imaging, rather than from the nearest road. Currently available online street views of farms are mostly inadequate, failing to show processes and procedures carried out on farm (see Figure 1). Additionally, information about seasonal change is not available. Detailed descriptions of the farming enterprise are also unavailable for much of rural Australasia. The co-operation of multiple veterinary schools across Australasia will allow access to different properties in different states. This gives students access to diverse “virtual” properties with different animals, infrastructure and climate and allows them to “visit” more properties than they can physically visit during their veterinary or agricultural degree. It also allows the cooperation and collaboration of veterinary educators across Australasia to produce a combined resource for use in all Australasian schools with potential long term collaborative benefits to rural education in this area.

Figure 1: A view of a dairy farm at Caldermeade using Google street view (modified)

2. Development of a minimum of ten virtual farms with a mix of different enterprises (beef cattle, dairy cattle, intensive farming and sheep production), climate and geography across Australasia with associated learning and teaching tools. Each farm surveyed for this project will have a survey map produced and photographs will be taken at “nodes” on this map (see Figure 2). Users will be able to open images at these “nodes” for 360 degree viewing and zooming. Users will also be able to move through time at each of these nodes whenever the property has had images.
collected. To provide an in depth experience it is envisaged that approximately 25-30 nodes will be required for each property. Particular attention will be paid to the areas involving animal handling to allow students to gain a better appreciation of this aspect of on farm veterinary work. This will also provide an understanding of occupational health and safety issues on farms. Funding from the Collier Trust has allowed a typical Australian dairy farm to be partially imaged to demonstrate that technology transfer from a chemical engineering environment developed from a previous ALTC project (2009 ALTC project: “The Engineering Design Journey – Needs, Concept and Reality”) to farm environments is possible (see Figure 2).

Figure 2: An example of a 4D diary farm environment (yellow highlight boxes demonstrate some features for users).

3. Students from different cultural or education backgrounds will be able to spend as long, or as little, time as they wish to review material without being judged. This platform has the ability to answer the majority of students questions as information is located on-screen and they can self-assess their understanding through integrated learning exercises embedded within the package. Standard photographic or video views will also be incorporated into this system where appropriate. For example, where high resolution images of particular situations, such as milking are required. The 4D farms site has many advantages over current systems of video and still
photographs as it allows the student to view the information over several seasons and understand the spatial arrangement of various elements on the farm.

4. The 4D nature of this project allows students to view change over farming seasons and the vital impact this has on animals and pasture. This is an important part of veterinary learning and something that is difficult to communicate adequately without 4D technology. The project team will also work collaboratively to evaluate learning environments such as that demonstrated by CrookMoo\(^5\) and potential adaptation and integration of this type of scenario planning into this environment. With collaboration between each contributing University, learning exercises for each property will be developed to accompany the 4D visualization. This will include “hotspotting” items in the 4D environment to explain their function and importance to the running of the farm. Provision can also be made for students to access assessment tasks or activities to provide information in greater depth.
Chapter 3: Methods used & outcomes

This project built on knowledge gained in a previous ALTC funded project from 2009 “The Engineering Design Journey – Needs, Concept and Reality" with significant changes to suit learning and teaching within veterinary and agricultural science and inclusion of novel techniques not available at the time of the earlier grant.

Produce an authentic reproduction of real life scenarios on farms across Australasia

The most important aspect of this project was the selection of the best candidate for the role of project officer and the cooperation between the veterinary schools, particularly the staff from each school and faculty involved in this project and subsequent collaboration with farming properties. The model chosen for this project was to achieve as wide a geographic representation across Australasia as possible and this was achieved with the collaboration of The University of Melbourne, The University of Sydney, The University of Queensland, Murdoch University and Massey University (New Zealand). Further input into the project was obtained from staff at The University of Adelaide and Charles Sturt University with a review of the project after 2 years. This covered almost all Australasian veterinary schools and a number of agricultural schools.

A number of agricultural enterprises representative of those commonly found throughout Australasia were selected by project members at each partner university (Table 1: Property types and locations of 4D farms). This had two main benefits: Generally the property owners or managers had an existing relationship to the local project partner and this helped start the project more rapidly. This also assisted in selecting areas on the property most likely to be a benefit to students learning. Property owners could give detail regarding expected change on the property over 12 months or more, helping to ensure the usefulness of the project at all the universities.

Once properties were selected it was important to select the relevant areas on each property for 360 degree imaging. Prior to commencing imaging ten intended learning outcomes (ILOs) for the project were developed to aid in the selection of relevant sites to collect images from. These ILOs are detailed in Table 2. On each property up to 30 locations of interest (nodes) were selected following discussions with the property owner on which areas of the property would be most useful over 12 months of imaging. This involved knowledge of what changes were expected in that time over cropping, pasture and livestock rotations as well as seasonal impacts on fodder storage, water supply and other areas likely to change over that time.
Table 1: Property types and locations of 4D farms

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merino/Wheat/Canola</td>
<td>WA, Australia</td>
</tr>
<tr>
<td>Dairy</td>
<td>North Island, New Zealand</td>
</tr>
<tr>
<td>Terminal sire sheep/Wheat/Canola</td>
<td>WA, Australia</td>
</tr>
<tr>
<td>Sheep/Beef</td>
<td>North Island, New Zealand</td>
</tr>
<tr>
<td>Beef stud</td>
<td>Victoria, Australia</td>
</tr>
<tr>
<td>Terminal sire sheep stud</td>
<td>Victoria, Australia</td>
</tr>
<tr>
<td>Merino &amp; Beef</td>
<td>NSW, Australia</td>
</tr>
<tr>
<td>Dairy</td>
<td>Queensland, Australia</td>
</tr>
<tr>
<td>Tropical Beef</td>
<td>Queensland, Australia</td>
</tr>
<tr>
<td>Pigs</td>
<td>Queensland, Australia</td>
</tr>
</tbody>
</table>

Table 2: Intended Learning Outcomes (ILOs)

- Explain the reasons for seasonal variations in pasture growth on different farms and describe how this influences the timing of livestock management activities.
- Compare and contrast the major inputs for different agricultural enterprises, their major outputs and how stock are managed to maximise their productivity.
- Describe the major factors that determine profitability for an agricultural enterprise, how to measure each factor and explain the practical steps that farmers can take to achieve this.
- Describe the role of genetics and nutrition in this animal production system and compare to other virtual farms - what are the similarities and differences?
- List the major management activities you expect would be undertaken on the property, when these should occur and rate some likely areas of potential animal health and welfare issues on the property.
- Be able to demonstrate an understanding of appropriate environmental health and safety procedures for different properties and recognise and be able to minimise major risks on livestock enterprises.
- List and describe some factors that may limit productivity of this enterprise and compare this to other virtual farms.
- Review the environmental (rainfall, temperature and evaporation) variation for this property and describe how this may impact on the decision making of the manager on a weekly, monthly and yearly basis.
- Detail how a farm manager can make use of relative feed surpluses and cope with feed deficits throughout various times of the year – what strategies can be used and how should a manager plan for these.
- List and discuss the sorts of objectives that a farmer may have for this property in any year.
Seven hi-resolution images were captured at each node (see examples at Figure 3). These images were aligned and blended using the open source software Hugin 2013 to create 360° panoramic images (Figure 4). Each node position was recorded using a Global Positioning System (GPS) so that the exact location could be photographed at future dates and allow the development of an accurate property map with “nodes” at the correct position. Properties were rephotographed a number of times over multiple seasons to create the fourth dimension in the project, time (Figure 5).

Figure 3: Seven images required for each “node”: 60 degree increment horizontal and one directly up.

![Figure 3: Seven images required for each “node”: 60 degree increment horizontal and one directly up.](image)

Figure 4: Seven images stitched into single image to allow full 360 degree view

![Figure 4: Seven images stitched into single image to allow full 360 degree view](image)

Rather than share all information via posting hard drives, an HTML5 web based interface was developed, which allowed for 360° rotation around the panoramic photos, as well as the ability to transition between each of the time periods captured (Figure 5). This interface was particularly useful in sharing project progress with property owners/managers and collaborators as everyone could observe the most recent images once they were completed. To allow the user to orient themselves, the interface included a map showing the users current position in the farm, plus a compass and map pointer to help the user orient themselves.
themselves in the virtual farm. Each node contained “hotspots”, which would transport the user to the next node or display other multimedia such as video. When viewed on Apple iPhone or iPad, users could use the devices gyroscopic capability to rotate around the scene by physically rotating the device. The use of HTML5 allows the site to be viewable on all operating systems.\(^7\)

Figure 5: Two screen shots of the 4D farm interface, comparing changes at different times of year. January 2013 (left) and August 2013 (right). Differences in pasture quality and growth are easily identified.

![Figure 5](image)

Figure 6: Illustration of the key features of the 4D farms site

![Figure 6](image)

*Blue oval = dates of image collection, Yellow ovals = methods to move around the property on any given date, red oval = compass to allow directional orientation, green oval = graphical representation of rainfall or temperature.* These elements can all be shown on screen or minimised to reduce screen clutter.

Development of 4D farms to improve student learning and safety
Develop a minimum of ten virtual farms with a mix of different enterprises

As noted in Table 2, ten virtual farms were produced from this program stretching the length and breadth of Australia and to the North Island of New Zealand (Figure 7). This selection of properties included a majority of extensive grazing properties including beef cattle, dairy cattle, wool sheep, terminal sire sheep and prime lambs; but also included an intensive piggery. The intensive piggery was only visited once due to the minimal change anticipated in appearance over the course of a year. All other enterprises were visited three or four times over the two year duration of the project, with most visits occurring over a twelve month period.

Property visits were coordinated from The University of Melbourne and were generally conducted with support from the local university representative with or without the farmer’s assistance over repeat visits. On some properties such as “Ferndale” in New Zealand the property manager assisted on each visit due to their knowledge of terrain and for EHS reasons. These visits at times were challenging given that trips were generally organised weeks in advance and photographs could not be taken in the rain. This resulted in some days when images could not be collected due to rain, or travel around the farm was too dangerous given local weather or driving conditions on farm, particular in steeper country during wet conditions. The quality of photographic equipment being used and careful planning allowed this to be minimised. Despite this planning, more than 100 person days were spent in the field collecting images and video for the project on or project travel.

Figure 7: Screenshot of the front web page of the 4D farm site
Figure 8 The four seasons at a sheep property in NE Victoria shown in the 4D farm

Spring 2013  Summer 2014

Autumn 2014  Winter 2014

Figure 9: Range of properties – differences in topography, climate, grass types, cropping and other variables.

New Zealand Sheep/Beef property  Victorian Angus/Charolais stud

Queensland Santa Gertrudis stud  West Australia – Sheep/Wheat/Canola
Allowing self-paced learning, development of a glossary

While there are over 17,000 images (599,000MB) used to make up the base level version of the 4D farms there are a number of other images, videos and descriptive items that have been added to make up a “glossary” for the 4D farms. This glossary, developed using hypertext pre-processor (PHP) code was developed to allow students to search all properties and view descriptions of what they can see on screen (Figure 10a).

The use of this database allowed the development team to highlight an image within an individual farm, at an individual time point, a particular direction and zoom level. This is highlighted using a flashing widget or “hotspot” on the screen (Figure 10b). When the widget is clicked it allows the viewer to see whatever file has been inserted at that position (Figure 10c). These files can be any media files or Microsoft office files allowing developers to insert learning tools at appropriate places within the site. As the 4D farms is still retained as a website, this allows anyone in the development team to update terminology on-line if they wish or to make changes into the future if various terms change.

The glossary can be used in one of two ways.

1. Students can search the glossary list (Figure 10a) to look for a particular term to find the written definition and then be taken directly to the position on the property to visualise it. This allows the student a very rapid, visual answer to a question.

2. Students can go to the glossary web site and review all of their knowledge via a “self test” where they visit each farm and find the flashing widgets to anticipate what the definition will be. Technically this also allows the 4D farm to be set up for assessment purposes, although this has not been assessed during this project.

The glossary is particularly important for student learning in environmental health and safety (EHS). On each farm visited the areas that most commonly result in injury were noted for future use in the glossary. This then allows the insertion of relevant information into the glossary under the format EHS: Item. Students can then search for EHS or scroll alphabetically and see all the areas required for learning in this domain. Development of the glossary tool is complete however considerable work is still required to list all the required definitions in the glossary and this will occur over the next twelve months using staff and student feedback.

Staff are also able to save a particular view of the 4D farm using an editor tool. This means that they are able to open the 4D farm at a particular property, on a particular date, in a particular direction and zoom level. This function is particularly useful if demonstrating a particular image in a lecture without needing to click through the various screens and find the position you want to show to students. It can also potentially be used by students to save a response to a set question from a lecturer to demonstrate a particular feature in answer to a question eg. A case study question.
might be “Find two examples on different properties of fodder storage”. A student could then save both points in a wiki and this could be assessed very rapidly by clicking the links (either by peer review allocation or teacher).

**Figure 10a** Development of a visual glossary

**Figure 10b** Interaction between glossary & 4D farm

**Figure 10c** Insertion of audiovisual or Microsoft office files into 4D farm, for example, video.

**Seasonal change – integration of rainfall/temperature**

One of the key learning outcomes from the 4D farms for students is understanding the impact of seasonal change on extensive livestock enterprises. On some properties seasonal change is dramatic, such as in WA. On other properties, such as the two properties in New Zealand, seasonal change is much less marked. This is difficult to convey in words however images in Figure 11 demonstrate this change well. Similarly the images from the cropping
properties in WA demonstrate changes in crop rotation between years from canola to wheat and pasture over the course of the year also across the property.

**Figure 11: Demonstration of seasonal change in different environments – WA on top row, NZ on bottom**

<table>
<thead>
<tr>
<th>SPRING</th>
<th>SUMMER</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Spring WA" /></td>
<td><img src="image2.png" alt="Spring NZ" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Summer WA" /></td>
<td><img src="image4.png" alt="Summer NZ" /></td>
</tr>
</tbody>
</table>

One of the key elements added to the 4D farms as the project progressed was the addition of a rainfall/temperature button at the bottom of the screen (Figure 11). This allows the user to view the variation in temperature and rainfall on the property and also what the pattern had been leading up to the particular visit. Each visit is highlighted by the presence of a vertical dotted line within the rainfall or temperature chart. Data for these charts was downloaded from the nearest bureau of meteorology site to each property.
Chapter 4: Key factors in project outcomes

The key factors in achieving the goals set out at the start of this project were:

- Identifying and employing a project officer with a broad skill set as this position was critical to the success of the project. This skill set required the following attributes:
  - Proficient photographer/videographer
  - Four wheel driving skills and farm safety skills
  - Basic understanding of livestock
  - Planning and resilience to cope with project change in the field
  - 360 imaging
  - Web design/management
  - Coding skills eg. PHP for glossary database development
  - Others as needed

- Identifying a team to collaborate on the project and for the team to identify appropriate properties willing to be involved. This process was vital to the success of the project as significant expense was incurred in each property visit hence losing properties from the program would have made meeting the property milestones challenging. The collaborative design of the project worked well in generating a positive start to property visits. We were also fortunate that property owners were generous with their time and enthusiastic about the benefits of training veterinary and agricultural science students.

- Designing a method of communication so that all people in the team (University staff and farmers) were kept updated on progress and could view the images. The development of the website solved many of the initial problems that were anticipated in this area as the early goal was to have the program available on hard drive only. A combination of website, email, meeting at various conferences and telephone kept team members appraised of what was happening and enabled planning relevant visits to properties.
Chapter 5: Deployment and use

For the purposes of wider dissemination amongst initial collaborators a website was developed on a server at The University of Melbourne. While this was not part of the original objectives of the program it allowed more rapid communication between project partners, including property owners, and each University for the duration of the project. This website will be maintained in the short term to facilitate feedback from students and teaching staff over the next twelve months to aid further improvement, particularly in the glossary section.

The site has been used across all Universities involved in the program as well as being reviewed for use at Curtin University. As building of the site has been ongoing it has not yet been fully integrated into any University curriculum. At The University of Melbourne it has been used in lectures, case studies and also in assessment tasks. This use has extended over four subjects in the first two years of the course teaching animal health production systems and animal management. The 4D farms site is an excellent tool for introducing students to the changes that happen on a property over a twelve month cycle and how this appears on a real farm. This has been used initially in a lecture setting to demonstrate what happens followed by more self-directed learning during case studies and problem based learning sessions. In its current web version this is simple with good internet access and also acts as a useful introduction to students in use of the system. Students or staff who have not previously used the 4D farms are able to access a short video on Vimeo that explains the basic functions of the 4D site and the glossary site. This was added after feedback from the first year review.

The 4D farms site can be used in problem based learning exercises or case studies in small groups by posing certain questions or activities for groups to investigate using the farms as a model. This can be used as an activity to review the intended learning outcomes shown in Table 1. It might include such questions as what is the ideal lambing or calving time on the property and describing reasons why the property does lamb or calve at that time or a different time. Similarly students can view the stock classes on the property and devise a management calendar based around what they can see on the property combined with rainfall and temperature data.

The 4D farms website can be integrated into most proprietary learning management systems (LMS) as shown in Figure 12 from The University of Melbourne LMS. This allows a lecturer to insert the 4D farms view into a window within the LMS and students can then interact with the full capability of the 4D farm to aid answering questions, rather than a static image. Similarly, students can access the glossary to find relevant answers to questions by searching for information. We also envisage utilising the 4D farms for oral exams in the final year of the course at The University of Melbourne as students will have
viewed properties previously and greater detail can be provided in the question compared to a verbal description.

Figure 12: Using the 4D farm inside the University Learning Management System for assessment
Chapter 6: Project publications and recognition

Journal publications
Currently being prepared for submission to the Journal of Veterinary Medical Education: “Collaborative development of a four dimensional farm learning platform for veterinary students”. Barber S, Hallein E, Weston J, Jacobson C, Bramley E, Celi P, McGowan M and Shallcross D.

Data to be collated across at least 2-3 universities on student experience using the site in 2016/2017 for future publication.

Conference presentations
December 2012: First Australasian Ruminants teaching workshop, Parkville, Australia, “Development of a 4D farm model to improve student learning and safety”

May 2014: Australian Veterinary Association Conference, Perth, West Australia “Collaborative development of virtual 4D farm systems for veterinary education”.

August 2014: World Buiatrics Congress, Cairns, Queensland, “Development of virtual four dimensional farm systems for veterinary education in Australasia”.

December 2014: Melbourne Academy of Veterinary and Agriculture Learning and Teaching – Innovative learning and teaching: the why and the how, Parkville, Victoria “Development of four dimensional farm models and learning resources to improve student learning in agricultural and veterinary science”.


May 2015: Australian Veterinary Association Conference, Brisbane, Queensland, “Collaborative development, integration and use of virtual 4D farm systems”.

September 2015: International Veterinary Simulation in Teaching Conference, Hannover, Germany, “Collaborative development, integration and use of virtual 4D farm systems”.

Seminar presentations
February 2014: Faculty of Veterinary and Agricultural Science Learning and Teaching Forum, Werribee, Victoria “4D virtual farms; a new learning tool for veterinary and animal science students”.

December 2014: Faculty of Veterinary and Agricultural Science Parkville Seminar Series, Parkville, Victoria “Demonstration of Virtual Reality, 4D farms and 360 degree video in veterinary education.”


July 2015: Australian Wool Education Trust meeting, “Overview of 4D farm”.

Submitted for review

September 2015: Australian Innovation Awards (Shell) – awaiting review.

Press articles
May 2013, Veracity – Newsletter for veterinarians in education research and academia, “The 4 dimensional virtual farm project”.


October 2014, Australian Sheep Veterinarians Newsletter, Skirting the Issues: “A new tool for helping veterinary students develop their understanding of animal agricultural systems – the 4D farm in Australasia”.

Upcoming (2015), Boundless plains to share, Rural publication, Chapter on Agricultural Education.

Social media
To facilitate knowledge on the 4D virtual farms site within social media a twitter account has been curated: @4DVirtualFarm. This account has 281 followers and has posted more than 450 times since commencement. The most common hashtag associated with postings is #4dfarms and #agvetedu.
Chapter 7: Future

The development of the 4D farms site allows a new method for educators to demonstrate what happens on rural properties. This is the first time that this has been done on such an extensive basis with 360 degree images through time with a user interface (UI) that is simple to explore. The last ten years has seen incredible advances in consumer/prosumer audiovisual equipment, and particularly in the area of 360 degree imagery. It is thus difficult to make significant predictions as to how education in general and in particular veterinary and agriculture science education will utilise new technologies including the current 4D farm in the coming ten years. Analysing the past five years however is a good guide to the potential changes that we can expect and how the current technology may add to a student’s learning experience. The last six months of this OLT grant has allowed us to consider how the 4D farms model may be placed within some of these innovations, particularly with respect to changes in the next one to two years.

1. 360 Video:

At the commencement of this OLT grant it was not possible to easily record 360 degree video but this is now feasible and we have inserted a low resolution example of this into the 4D farms website (Kennedy Creek, Winter 2014, added hotspot over sheepyard). This uses a combination of a number of GoPro cameras that are synced and images can then be stitched to provide a full 360 degree view for the viewer – in this instance 6 cameras were used mounted on a 360 Heros mount (www.360heros.com) (Figure 13).

Figure 13: 6 GoPro 3 + cameras mounted on a 360 Heros system for recording 360 degree video
Stitching these videos requires the use of specialised software such as Videostitch (www.videostitch.com.au). The combined weight of this GoPro 360 unit is less than 1.1kg making it extremely portable and able to record in 4K video. While this infrastructure and software was groundbreaking, it does take significant time to produce high quality videos that are well stitched together to avoid artefacts. New 360 cameras are now starting to become available that are designed to achieve a similar outcome but with less work – this includes new cameras such as sphericam V2 (www.sphericam.com) which was recently funded via kickstarter and several other commercially available models such as Kodak PixPro SP360. These provide 360 video of varying quality but without the complexity of stitching and editing as they output a file suitable for viewing in 360 degrees. This new technology makes recording 360 video possible for the average person, hence it is likely it will be increasingly utilised in education to demonstrate a full 360 view.

2. Virtual Reality

Aligned with the production of 360 video is the ability to watch films in immersive 360 video using head mounted displays. Oculus Rift is one of the best known of these systems and this company has recently been purchased by Facebook. Development of applications for mobile phones also allows the use of mobile phones as 360 viewers either in home-made viewers such as Google Cardboard or via purpose designed phone kits such as Gear VR (Samsung). The goal of all of these systems is to totally immerse the viewer in the 360 environment. We have trialled this on the 4D virtual farm and it functions very well in limited testing within the Oculus Rift DK2 and also on mobile phone platforms. If you are wearing these devices on your head and look for a few seconds at the arrow that points to the next “hotspot” this will automatically move you to that spot once some adjustments are made to the 4D farms site. You can then continue around the farm using this method, much like undertaking a pasture walk. Touching one key on the keyboard will move you through time while you are immersed in this environment enabling a far more immersive experience.

3. Augmented reality

The 4D virtual farm is about bringing the farm into the classroom. One aspect not considered in this application is how we might bring the classroom to the farm. Augmented reality applications can bring a range of material to areas on-site. For example, using an application such as Aurasma (www.aurasma.com) a lecturer can enable students to visualise material “on-farm” when the viewer points a mobile device at a particular symbol and then receive a multimedia file such as a video, providing information on a particular object or area. This acts to augment the real view that the student can see. This has significant potential as a learning aid for self-guided learning in the situation where students frequently visit a certain property, as
each property may require separate teaching material to be developed. Students may then access the same videos back at University so they can reflect on their learning on property.

4. Changing the view

The 4D farms demonstrate change over significant periods of time at eye level as this is the height that all images were collected to enable a constant viewpoint. A number of cameras now exist that can take long term time lapse to help fill in the gaps between some of the high quality 360 degree images that we have collected on the 4D farm. These images can be collated as AVI files to be displayed as short videos to show what happens over weeks or months to aid the viewer in understanding what happens. It is now also possible to collect images from the air via the use of unmanned aerial vehicles (UAVs). This provides a whole new perspective on animal handling that could be beneficial for students (Figure 14).

Figure 14: Aerial view of sheep yards in Tasmania showing stock movement using GoPro cameras (thanks to @DroneAg for flying our cameras). This image is a stitched image from four cameras.

5. Broadening the scope of 4D farms

The 4D farms program has proven to be very successful with significant international interest in the site following presentations at Cairns (World Buiatrics Conference) and Hannover (InVEST). It would be useful to have further international properties and a number of discussions have occurred investigating the potential for adding further properties to the 4D program. As most Australasian veterinarians are able to practice in Europe and the USA following graduation, information on farms in these areas as well as other countries would be highly beneficial to training students in Australasia and also in the USA or Europe. Producing 4D farms in countries
throughout SE Asia would also be beneficial to demonstrate the variation in farming systems and size of properties throughout the world. Development of this sort of site could aid extension of agricultural knowledge in countries with fewer teaching facilities and also provide better knowledge to Australasian veterinarians as to how agriculture is practiced in these countries.

6. Translation of the technology
We believe that this technology has many potential applications from demonstrating change in streetscapes over time from an architectural point of view through to reviewing natural resource management over time and through different seasons. The list of possible applications where a viewer needs to see full 360 degree view to observe change through time is large and diverse and we anticipate that this will become far more common over time. The concept of viewing in 360 degrees has already become common within the housing sales industry with startup companies such as Scann3D (facebook/scann3d) providing these services.

7. Reducing the rural/city divide.
The key goal of this project was to produce a resource for the education of tertiary level students. During the course of developing this material it has become clear that this type of resource has much broader application to educate the general public about what happens in agriculture. While further work is required to make the site suitable for all ages, we hope that it may be possible to continue this work to reduce the gap in knowledge between rural areas and the city for those who wish to understand more.

8. Further evaluation of 4D farms technology on learning and teaching
As the 4D farms project has only recently been completed and areas such as the glossary still require some additional material it has not been possible to complete some of the student feedback anticipated during this project. This will be performed during 2016 with feedback from both veterinary and agricultural students and staff to help inform future work and how it is used within teaching. Once complete this work will be published in a peer reviewed journal to demonstrate the impact of the technology on learning.

9. Gamification
One final area for future evaluation is in the area of gamification of the technology. There are a number of potential avenues for exploring this area either with existing images or capturing new images for photogrammetry. Gamification using the existing resource could be via building an app for users to go through a series of team based exercises using their knowledge to decide on a winning team utilising a scoring rubric incorporating material relevant to the topic. Alternatively, it could be more in the genre of first person gaming working on a range of skill sets including...
animal handling, management and other related skill sets. This could use either real-life footage or cartoon images, depending on the required learning outcome.
References or bibliography


2. 2011, Barber S, Hinchcliff K: Residential experiential workshop for first year veterinary students, VERA, Australian Veterinary Association conference


5. 2012, Mansell P and Beggs D; “Development of a computer simulation to teach the methodology of the clinical examination of cattle”, World Association for Buiatrics, Lisbon


Appendix A

Certification by Deputy Vice-Chancellor (or equivalent)

I certify that all parts of the final report for this OLT grant/fellowship (remove as appropriate) provide an accurate representation of the implementation, impact and findings of the project, and that the report is of publishable quality.

Name:  

[Signature]

Date: 30/10/15

Professor Richard James
Pro Vice-Chancellor (Academic), The University of Melbourne
Appendix 1: Basic User Instructions

Instructions

Go to the website in a web browser. The 4D Farms main screen should appear with a list of farms.

Click on one on the farms. This will bring you to the home screen for that farm. Note the farm information shown.

Click “Enter the Farm”. A popup window will appear and the 4D farm will load.

The interface is shown below. You can pan with mouse or use the keyboard arrow keys. Zoom in using either the mouse scroll wheel or the “A” and “Z” keys on the keyboard. You can also use the interface buttons if you wish.

Each farm contains a number of nodes. You can jump between the nodes by clicking on the arrow hotspots that are located in various spots on the panoramas.

Most nodes have been photographed during a number of different seasons. You can change the date you are viewing by using the drop down menu in the top left of the screen.
Clicking the map icon 🌍 at the bottom left of the screen brings up a map of the farm. You can also move around the farm by clicking on the dots on the map.

A third way to move between nodes is to click on the thumbnail icon 📚 at the bottom left of screen, then scroll though the images and click on the node you wish to travel to.

The graph icon 📊 at the bottom left of screen will bring up graphs of rainfall and temperature for the period the images were taken, plus the previous year. You can change the data types shown using the drop down menu. The vertical dashed line indicates the date currently being viewed.
Appendix 2:

Initial meeting of OLT Review Committee for “Development of 4D farms to improve student learning and safety”.

Date: 14/6/2014

Attendees:

Stuart Barber, Project leader
Evan Hallein, Project Manager.
Chi Baik, Centre for the Study of Higher Education, The University of Melbourne
Colin Wilks, Professor of Veterinary Science, The University of Melbourne

Agenda:

VENUE: The University of Melbourne, Faculty of Veterinary Science, Parkville: 3rd floor teaching space (area for teaching students with the 4D farm environment noting other schools have different facilities). I envisage that this will take approximately one to two hours.

1. Preview what is currently available in the 4D farms environment
   a. Actual 4D environment
   b. Various tools within environment – video, photos, spreadsheet, powerpoint etc
   c. Way to bring the environment into teaching/assessment – inserting links to particular sites, database for glossary in development (and other tools), inbuilt MCQ option or using images within LMS
2. Preview what other tools are likely to be developed and how we will generate feedback on the 4D farms from staff and students.
3. Feedback on performance thus far and identify potential areas for improvement in design or extra tools that would be useful.
4. Identify areas for improvement in collecting data for demonstration of improvement in student learning.
5. Other?

Minutes:

Review committee meeting commenced at 10:05 am

1. Evan Hallein and Stuart Barber detailed the main reason for development of the 4D virtual farm program
a. Change in student demographic and increase in students from non-rural and non-Australian backgrounds. It is envisaged the 4D farm may assist all students, but particularly non-rural students understand agricultural terminology and improve their safety on farms.

b. Allows students to review what happens on farms prior to and following actual property visits to ensure they understand various concepts.

c. Ensure students gain the most possible from property visits, particularly when conditions may not be ideal (such as rain or adverse temperature)

d. Allow students to virtually visit similar types of farms in different areas of Australasia during different seasons that may not be possible due to budget or time constraints.

e. Allow staff to propose realistic visual scenarios for assessment purposes

2. Preview of the six virtual farms

These views demonstrated the following components of the program

- 3D and 4D nature of each property with the ability to move around the farm via “hotspots”, “picture windows” or via line of sight arrows on the display
- High resolution nature of the current version of the program compared to the version prior to commencement of the OLT program
- Ability to locate a particular spot on a property, at a particular time, particular view in the 360 arc and at defined zoom level and export this to a file to allow a later view direct to this view
- Ability to import the 4D environment into wordpress to ask multiple choice questions or open ended questions about the view
- Ability to “hotspot” items in the 4D farm and add file types associated with this – video, picture, sound etc.

3. Demonstrated the ability to use material from the 4D farms as a component of assessment within The University of Melbourne learning management system. This could either be via cutting out an image and inserting directly or via pasting the link to a set point in the 4D farm environment into the LMS. Similarly this could be done within wordpress allowing flexibility in how the program can be utilized.

4. Demonstrated the initial development of a database tool to avoid a requirement for staff to know how to develop code. When completed this should allow staff the click on a relevant object on the screen, insert information about this object and create a “hot spot”.

5. Discussed the development of the properties and interaction between different universities including the development of global intended learning outcomes for the program to ensure that common goals were identified and achievable. These goals determine imaging on each property.

6. Discussed the flexibility of the 4D farms for use in lectures, case study, problem based learning – different modules will be available for different areas including a base level 4D farm, a glossary 4D farm and other additions as they become available.

Feedback on performance:

The overall feedback on the performance of the project from the reviewers was that the properties produced from the work will be very useful additions to teaching agricultural and veterinary science and the project is producing a very high quality teaching resource. The quality of the images is
very good and allows visualization of required areas for teaching and learning purposes. The ability to use the program in various ways allows it to be used flexibly and not constrain staff to using it in a particular way. It was noted that the 4D farms concept could be very useful across other industries that students need to understand. The development of intended learning outcomes across the properties at the commencement of the program to facilitate greater engagement and agreement across universities was also a useful starting point for the project. In general, the project was progressing at a quality level above the original expectations of the application.

**Identify areas for improvement:**

There were few deficiencies noted in the development of the program so far. It was suggested that a guide to use of the 4D farms be produced, particularly to assist early career academics utilise the program to its maximum. This may include a summary of potential uses and include examples of how staff at participating universities use the program, or intend to use it.

**Meeting closed 11:40**
Appendix 3:

Title: Final meeting of OLT Review Committee for “Development of 4D farms to improve student learning and safety”.

Date: Individual meetings were held between Drs Barber & Wilks and Drs Barber & Baik on 16/10/2014 and 26/10/2014 respectively

Agenda:

VENUE: Room 216, The University of Melbourne, Faculty of Veterinary Science, Parkville: Approximately one hour for each meeting.

1) Preview updates from last meeting in the 4D farms environment
   a. Actual 4D environment
   b. Various tools within environment – video, photos, spreadsheet, powerpoint etc
   c. Way to bring the environment into teaching/assessment – inserting links to particular sites, database for glossary (and other tools), inbuilt MCQ option or using images within LMS
2) Feedback on performance and identify potential areas for future improvement
3) Other?

Minutes:

1. Stuart Barber demonstrated the updates to the 4D farms since the last meeting
   A. Within the main 4D farms environment these updates consisted of additional visits to each property where these were not completed by previous meeting.
   B. Included updates to rainfall and temperature tool on each 4D farm.
   C. Included fully functional glossary tool – video, word, image etc.
   D. Demonstration of the insertion of 360 video into the 4D farm in the Kennedy Creek property
   E. Demonstration of the use of Oculus Rift (using Oculus Rift DK2) for viewing the 4Dfarms and using hotspots. Impact of virtual reality
   F. Demonstration of the use of “Google Cardboard” for the use of the 4D farms
   G. Demonstration of the use of hotspotting within 360 degree video
   H. Illustration of the integration of the 4D farms in teaching – lectures and case studies and for revision/assessment.

Feedback on performance:

The overall feedback on the performance of the project from the reviewers was that excellent progress had been made on the site and that it was highly interactive and fun to use. The inclusion of some new technologies aided the illustration of important key points. The site was simple to
navigate and showed a large number of images in a logical manner that should be an excellent aid in teaching and learning. Both reviewers felt that the technology had potential to be used across a number of different teaching areas and that the program had been very successful.

**Identify areas for improvement:**

The main area suggested for further benefit was increasing the number of examples of how the site could be integrated into teaching as this may increase uptake across all schools. Most other suggestions for improvement were in potential future extensions of the site such as widening the geographic spread and the integration of other new technologies that would aid the site become more immersive as discussed during the meeting. It will be particularly useful to get more student feedback on the site to demonstrate the impact that it has on the student learning experience.
Appendix 4: Some suggested ideas for integration of the 4D farms site into teaching

The 4D farms site is very flexible as to how it can be used in lectures, practical classes, case studies, case conversations, small group learning and a range of assessment types.

The basic 4D farms site is composed of almost 20,000 images from properties across Australasia, all seasons of the year and compares a range of different extensive and also intensive agricultural production systems. This means that for most veterinary or agricultural images you are trying to illustrate to students you can quickly go to the type of farming operation and right time of year by selecting relevant properties and seasons. If you have not spent much time looking at the 4D farms it may take a little while to explore the property, however this allows an understanding of what students will need to do and how long it may take them to complete various tasks that you might assign them. It is worthwhile spending a few hours to familiarise yourself with the structure and layout of each farm prior to utilising them in classes to familiarise yourself with the property.

Ideas for use:

1) Within lecture
   As a first introduction to the 4D farms it can be useful to give the students a property tour through one or more properties in a lecture or small group learning session. This shows the students the relevant buttons to click on and how you move around the property – it is also a really good way of demonstrating some important learning outcomes for many lectures using the real farm examples. It does however pay to know the various parts of the farm relatively well prior to doing this in case students ask to see other parts of the farm or you want to answer particular questions by going to other parts of the farm.

2) Case studies
   Each farm on its own, or used for the purposes of comparison, allows students to demonstrate their understanding of the management system. The intended learning outcomes can be used as starting points for asking students to demonstrate their understanding of particular areas and then expanded on in more depth.

3) Using the glossary
   The glossary allows students to visually access definitions of words or phrases. The tool allows this to happen either from students first looking at the glossary word and definition and then viewing on-farm, or alternatively looking at hot-spots on the farm first and clicking these to view the definition. This allows it to be used as a tool for self or group guided exploration or alternatively it can be used as an assessment tool for students to describe what is under a hotspot prior to clicking it for an answer.

4) Utilising the finder
   A key tool of the 4D farms system is the ability to save a link to a particular place on the 4D farm at a particular time, direction and zoom factor. A lecturer can use this to insert into a
powerpoint so that they can rapidly show a class a particular image. A student may also find this useful to answer a question posed in a case study by a lecturer to include in their report to demonstrate they understand a particular learning outcome by showing what a certain answer should look like and when this would occur on a particular farm.

5) Within a learning management system

Within a learning management system the 4D farms can be inserted as an “iframe” using the web address. You can then put in comments or questions about the image that the student can see, but they are also then able to view the complete functionality of the 4D farm. Alternatively, you can copy and paste a screen shot of a particular view from the farm which also has the time of year to then ask questions or exercises for student learning.