Increasing the Employability of Agriculture Graduates through the Development of Eal Industry Technology Learning Systems: Examining a Case Study in an Online Farm Mapping System (PA Source)

Amy Cosby[a], Mark Trotter[b], Ben Jones[c], Tina Botwright Acuna[d], Wendy Fasso[e], Sue Gregory[a]

[a] *School of Education, University of New England, Armidale, NSW, Australia*
[b] *Institute for Future Farming Systems, School of Health, Medical and Applied Sciences, Central Queensland University, Rockhampton, QLD, Australia*
[c] *PASource Pty Ltd – Brighton, VIC, Australia*
[d] *School of Land and Food, University of Tasmania, Hobart, TAS, Australia*
[e] *School of Education and Arts, Central Queensland University, Rockhampton, QLD, Australia*

Abstract: There is a recognised skills shortage in the Australian agriculture industry, which is exacerbated by universities failing to keep pace in educating students in the latest agri-tech systems. A collaborative project between seven universities in Australia and the United States of America (U.S.A.), the SmartFarm Learning Hub (here forth known as "the Hub"), will develop real industry technology learning systems (RITLS) using real-farm data and commercially available systems that can be used in tertiary teaching to increase graduate capabilities and readiness for employment within the agricultural industry. Reported in this paper is the evaluation of one case study: the online farm mapping package PA Source and a survey of 71 students studying a first year unit at the University of New England (UNE), Australia, on their perceptions of the value of this RITLS in 2016. PA Source is a cloud-based software that allows a farm map to be created and precision agriculture data collected on-farm or from satellites to be stored. Seventy-seven point 5 percent (77.5%) of students who completed the practical and survey 'strongly agreed' or 'agreed' that they would use the knowledge developed from the PA Source learning module in their future employment. A statistically significant relationship ($P<0.05$) was found between the type of degree a student is studying and the probability they will apply what have they learnt in the practical in their future employment. As part of the action research cycle, the PA Source learning module will be enhanced based on student survey responses and delivered to a different cohort of students in 2017.

Key words: Tertiary education, technology enhanced learning, agri-tech education, farm mapping

Introduction

Introduction to practical and theoretical background

Agriculture is an important industry to the Australian economy with the gross value of farm production predicted to rise by 8.3% in 2016–2017 to be worth $A63.8 billion (ABARES, 2017). Agribusiness has also been reported as having the greatest potential of all sectors of the Australian economy to take over from mining as the key driver of economic growth (Deloitte, 2015). For agricultural businesses in Australia to remain competitive in a global market, they must continue to innovate and adopt new technologies (Australian Government Parliamentary Committee, 2016). If this is to occur, the agricultural workforce must have sufficient skills and knowledge of agricultural technologies that can increase production efficiency, environmental sustainability and profitability.

In 2015–2016 there were 282,000 people employed in agriculture in Australia (ABARES, 2017). Despite the recognition that the modern agricultural industry is complex and demanding, it still has one of the lowest proportion of workers with post-secondary

qualifications across the economy (Parliament of Australia, 2012) with an estimation of approximately 7.8% of the agricultural workforce with tertiary qualifications compared with 25% for the broader population (Pratley, 2012). Pratley and Acuna (2015) have also reported that there is already a skills shortage in the industry with an estimated four jobs available for every tertiary agricultural graduate in Australia.

Additionally, those students that are graduating with an Australian agricultural degree are doing so without gaining the fundamental skills and knowledge at the level required for the now greatly technical and rapidly changing environment. Key skills that require development include attaining a deeper theoretical understanding of new technologies and the practical ability to use them in an analytical and problem solving context (Trotter et al., 2016).

Purpose

The Hub (www.smartfarmhub.com), is an online resource that aims to increase the skills of students in the latest agri-tech tools and systems (Trotter et al., 2016) to meet a key gap in the knowledge of tertiary graduates identified by the Australian agricultural industry (Rural Research and Development Council, 2011). The Hub has been developed to address two key issues:

1. Provide students with the necessary skills and knowledge required for a successful career in the constantly evolving and increasingly complex and technical agricultural industry.
2. Engage and encourage students from a young age to undertake a tertiary study and a career in agriculture (Trotter et al., 2016).

To tackle these issues, the Hub will host a range of learning modules that utilise Real Industry Technology Learning Systems (RITLS). The use of Technology Enhanced Learning Systems and Environments (Wang and Hannafin, 2005; Zhu. 2015) and Learning Management Systems (Coates, James and Baldwin, 2005) in tertiary teaching is widespread. A RITLS is different to these systems as they use real, and at times live data from a farm in a commercially available, and industry recognised, agri-tech tool or system. There are currently very few learning activities focussed on industry relevant technology tools/systems, and even less with an emphasis on agri-tech. There are numerous benefits to students who complete these RITLS learning modules including:

1. Awareness of and the ability to use agri-tech tools and systems on their family property and/or in their future employment
2. Developing the skills and knowledge required to solve problems and make objective management decisions through the analysis of data to improve efficiency, sustainability, productivity and profitability across the agricultural value chain.

The Hub is a collaborative project with seven universities, namely the University of New England, University of Tasmania, University of Central Queensland, University of Southern Queensland, University of Melbourne, University of Sydney and New Mexico State University, each developing a learning module that utilises real farm data (and in some instances live data) within a RITLS (Trotter et al., 2016). Each of the partner universities has a farm with a diverse range of enterprises and environmental conditions represented. For example, the highly productive dairy systems in Tasmania to tropical beef production in Central Queensland and the arid rangelands of New Mexico (Trotter et al., 2016).

Education institutions in Australia and across the world are able to use any of the learning modules available on the Hub without charge and with freedom to amend the material to suit their teaching. This is because each of the RITLS learning modules, consisting of student and

educator resources, developed as part of the Hub are available via Creative Commons Attribution-ShareAlike licence (https://creativecommons.org/licenses/by-sa/4.0/legalcode).

Case description

Reported in this paper is one case study RITLS from the project, PA Source. The PA Source learning module was developed at the University of New England (UNE) by Dr. Mark Trotter, and taught to a cohort students studying the first year subject RSNR120 (Sustaining Our Rural Environment II) in August 2016.

Student cohort

Seventy-one students studying a range of degrees at UNE including Rural Science, Agriculture, Agribusiness, Environmental Science and Sustainability at UNE completed the survey allowing a preliminary evaluation of the learning module to occur at a first year level. The learning module was completed by internal (24%) and online (76%) students during a 1.5-hour practical session during the trimester or at the intensive school held at UNE in August 2016. The survey asked a series of questions to gather data on the demographics of the student cohort (Table 1).

Table 1. Demographics of students who completed evaluation survey.

Gender	**Response Count**	**Response Percent**
Female	28	39%
Male	42	59%
Other	1	1%
Age	**Response Count**	**Response Percent**
18 to 21	27	38%
22 to 31	26	37%
32 to 41	13	18%
42 to 51	5	7%
52 to 61	0	0%
62 +	0	0%
Place of residence when not attending university	**Response Count**	**Response Percent**
Rural – living on land/property	26	37%
Rural Town – less than 5,000 people	11	16%
Town – 5,000-18,000 people	12	17%
Major City – 50,000-250,000 people	15	21%
Capital City – 250,000+ people	7	10%

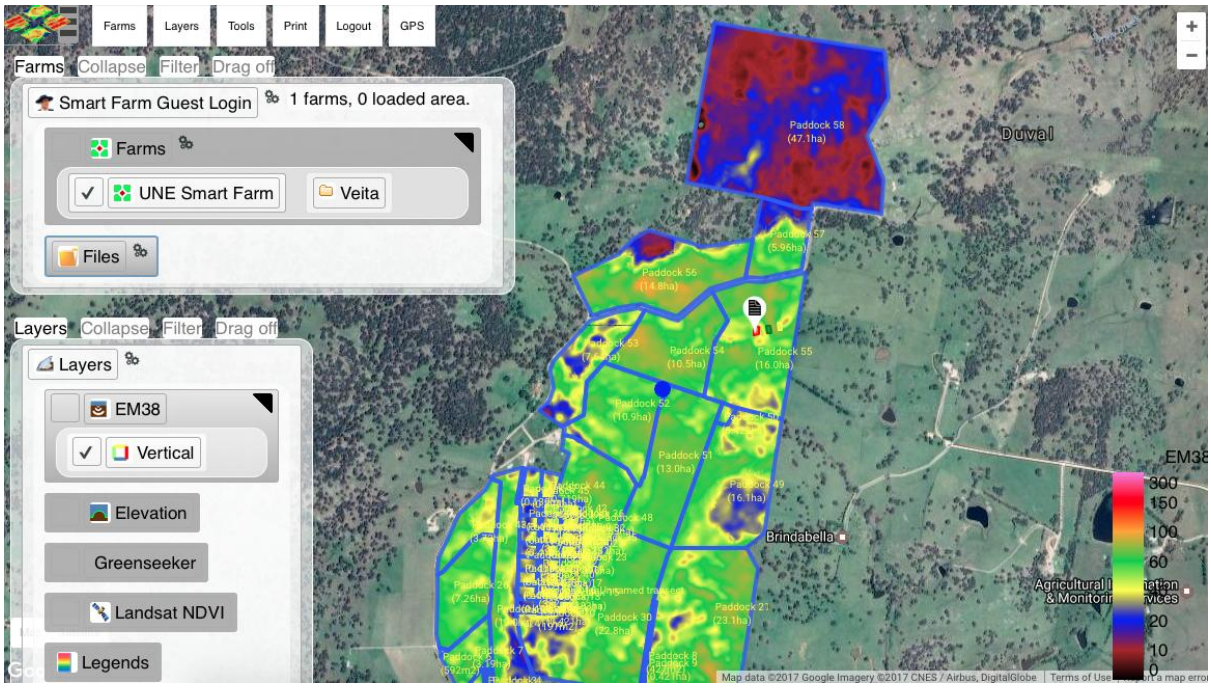
PA Source

PA Source is a cloud-based software platform that accumulates a range of agricultural indicators and spatial data relating to a farm (PA Source, 2016). Figure 1 illustrates the student view of PA Source when observing data layers, such as an EM38 soil map, for a property. The platform handles data processing on upload, analysis/manipulation, and facilitates sharing of a single farm with a range of users, and access for multiple users to a collection of farms (e.g. groups of consultants). PA Source also provides access to medium

and higher resolution satellite/aerial imagery through the related Watch.farm and PA Stack websites (PA Source, 2016).

PA Source's involvement with the SmartFarm Learning Hub project has had benefits for both parties. Educational institutions and their students have had free access to the software, and have been exposed to a commercially available product that they can use on their own farm, or in their employment. Additionally, it has been a positive association for PA Source with exposure to the wider Australian market including early-career and established professionals in agriculture, and even to high school students who are contemplating a future career in the industry. Ben Jones from PA Source notes that is has also been a "*great catalyst for improvements in the product, because there's nothing like a lab of fresh, uninhibited users, all using your product at once, to expose where improvements need to be made*."

Figure 1. PA Source displaying a soil EM38 map of UNE SmartFarm.



Structure of student practical

Students were introduced to the software by reviewing the data stored on PA Source for the UNE SMARTFarm before going on to map their own property, or a farm familiar to them. The introduction to an existing dataset on the system provides the students with time to assimilate the concepts and tools available to them. It also provides the educator with a consistent dataset upon which they are providing training. In addition, introducing students to an existing farm provides them with a view of all the features of PA Source that are available once they have developed their own dataset. Once the basic skills have been developed by students, they are then required to develop a map of their own further developing skills around the generation of spatial data. They are able to choose to map a property anywhere in the world, and as many have an existing relationship with a home or work-experience farm they usually pick to map it. This close personal relationship with the farm being mapped increases engagement as students are usually familiar with the various features of the landscape and often see significant value in developing the digital map.

Methodology

An action research methodology was utilised to evaluate each learning module to ensure that they deliver an optimum learning experience for students (Reason and Bradbury, 2001) and demonstrate best practice for RITLS. As part of this methodology students were invited to complete an online survey through SurveyMonkey® at the conclusion of the PA Source practical. The results and comments from this survey will be used to modify the learning module and students who complete the amended module in 2017 will be surveyed to evaluate whether the changes have led to improved learning outcomes.

A survey instrument will be used to evaluate the RITLS modules developed by each of the participating universities. The UNE Human Research Ethics Committee provided ethics approval for this study (Approval No. HE16-129). The survey was sent via email to students enrolled in RSNR120 at the conclusion of the practical for the internal students, and after the intensive school for the online students. Seventy-one out of the 291 students enrolled in the unit completed the survey, a response rate of 24.4%.

Thirty-four questions were asked of the students gauging their perception on a variety of aspects of the practical including whether it met its purpose in achieving learning outcomes and improving employability skills, the student's learning experience, technical aspects, system usability scale and demographic information. Students were asked to respond using Likert scale questions (Likert, 1932). There was an option to add a written comment for most questions. Here the researchers focus on two subsets of questions; gaining skills for future employment and achieving learning outcomes.

A series of three questions related to a student's perception of job skill developed as a result of completing the module were asked to ascertain if one of the key issues, increased employability, to be addressed by the project have been met. In order to identify the perceptions of students of the value of this learning module to their future employment, respondents were asked whether they thought it would increase their employability in the agricultural industry, whether they believe they are likely to use what they have learnt in their future employment and if they think the skills obtained would increase the value of their Curriculum Vitae (CV).

Five of the survey questions focused on whether the student perceived after the completion of the PA Source practical they had achieved the learning outcomes. The questions based on learning outcomes were derived from the Threshold Learning Outcomes (TLO) which form the Learning and Teaching Academic Standards Statement for Agriculture (AgLTAS) (Botwright Acuña and Able, 2016; Botwright Acuña et al., 2014). The AgLTAS TLOs were developed with input from academic, industry and students using a consensus approach to address the need for skilled graduates in the agriculture industry (Botwright Acuña et al., 2016). They also aligned with the existing policy for education and training, the Australian Qualifications Framework (Australian Qualifications Framework, 2013).

There are five broad TLOs with each subdivided into a range of criterion statements (Botwright, Acuña et al., 2016). One question for the following TLOs was asked: TLO 1 – Understanding Agriculture, TLO 2 – Knowledge of Agriculture and TLO 4 – Communication. Two questions in the survey were based on TLO 3 – Inquiry and Problem Solving (Botwright Acuña et al., 2016; Botwright Acuña and Able, 2016). These TLOs were chosen because certain criteria under each were thought to be most applicable to the student learning outcomes that could be achieved from learning modules that use RITLS.

Results and Discussion

The results will focus on the questions related to the purpose of the practical, to increase student's employability skills, and whether they perceived the AgLTAS TLOs had been achieved.

Employability questions

Student responses to the employability questions are displayed in Table 2. Overall, the response to this series of questions was positive with the majority of students answering 'strongly agree' or 'agree'. When asked whether they believed by completing the practical this will increase their employability in the agricultural industry 17% of students strongly agreed and 51% agreed (Table 2). One student also commented:

> *As the digital age moves forward, experts too must become mobile, and data ready at all times. Having knowledge about such technologies and how to implement them will prove fruitful.*

Other students indicated that the practical was a good introduction to farm mapping but to be useful in increasing their employability a more in-depth exploration of the topic is need. Student comments include:

> *Only surface level overview, a little too brief to be able to transfer to the workplace at this stage.*
>
> *Good opening into the field and how simple it can be to use software and how interesting it can be.*
>
> *Was a good introduction but probably not detailed enough for a significant job skill.*

This raises the issue of whether the topic of farm mapping is being taught in sufficient depth to increase the skill base of students to a level where they perceive they can apply these in the course of their employment. As this is a first year introductory subject, students will build on these skills throughout their degree. It may be useful to highlight to students that later year units will advance their knowledge and skills of this topic, and if it is of particular interest to an individual, point them in the direction of available elective units.

Students were also positive when responding to the question on whether they are likely to use the knowledge they have developed from the practical in their future employment with 15.5% strongly agreeing and 62% agreeing with the statement (Table 2). It has previously been reported that educational activities that involve the latest agri-tech systems are found to be interesting and engaging by students (Cosby and Trotter, 2014; Trotter, 2014). This practical also seemed to have the same effect on at least one student who commented:

> *This is the kind of work is what I really wanted to do when leaving school but ended up moving away from it, seeing it again reminds me how interesting the ideas and concepts of it are and makes me think I wouldn't mind going back into this field.*

When asked whether they perceived the value of their CV would increase from completing this practical the majority of students agreed (56.3%), however a large percentage (32.4%) were neutral. This might be due to student not knowing what skills employers are seeking (*"I am not an employer so I do not know what they want"*) or the discipline they will be employed in use an alternative type of software for mapping (*"Studying engineering, working in land development, I use six maps which is enough for me"*). Whether the degree a student is studying affected the likelihood a student perceiving they would use the knowledge developed in this practical in their future career is explored below.

Table 2. Results of initial study looking at student responses to employability questions after completion of PA Source learning module.

Employability questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Completing this practical will increase my employability in the agricultural industry	16.9%	53.5%	28.2%	1.4%	0.0%
I am likely to use the knowledge I have developed from this practical in my future employment	15.5%	62.0%	16.9%	4.2%	1.4%
My CV/resume will increase in value when I add the skills I have learnt from this practical	4.2%	56.3%	32.4%	4.2%	2.8%

Threshold learning outcome questions

Student responses to the AgLTAS TLO questions are displayed in Table 3. Over 50% of the student cohort 'agreed' or 'strongly agreed' that the practical had assisted them in achieving the specified TLO criteria at an introductory level. Of the students who completed the survey 22.5% 'strongly agreed' and 57.7% 'agreed' that their knowledge of contemporary issues in agriculture had improved. It is also clear that after completing the practical the students who completed the survey felt the practical increased their understanding of current opportunities in agriculture to solve dynamic complex problems with 22.5% 'strongly agreeing' and 53.5% 'agreeing' with this statement (Table 3). The practical also explained the role and relevance of agriculture or its related sciences, or agribusiness in society to most students, with 14.1% "strongly agreeing" and 59.2% 'agreeing'. Exactly how the practical achieved this cannot be drawn from the data however extensive discussion occurred between teachers and students throughout the practical and it may be that students felt that this contributed to these TLO's.

The majority of students also felt they were better equipped to choose and apply an appropriate tool to solve an agricultural problem with 14.1% 'strongly agreeing' and 59.2% 'agreeing' with this statement. However, a relatively high proportion of students (28.2%) also answered the question with a 'neutral' response, indicating that the practical could be modified to align better with TLO 3 – Inquiry and Problem Solving. It could also indicate that students who were not studying agriculture or related degrees were not confident after one practical in choosing appropriate tools to solve agricultural problems. One student recognised that the one practical session would not teach them everything they needed or wanted to know about PA Source but felt confident that they would be able to use the program to answer any questions that arose.

> *Not all things can be answered in one prac(tical), but for what we have done everything was answered and wouldn't be hard to use this to work through any questions*.

Another student indicated that the understanding they derived from the practical in choosing and applying an appropriate tool could:

> *...help both the farmer/grazier exceed yields, productivity, profitability, and above all save money which in the end is the pinnacle of success.*

However, there is one TLO that the PA Source learning module could be better aligned with. When asked whether the practical better equipped them to communicate what they had learnt with a range of audiences, a high proportion of students (40%) gave a 'neutral' response. This is consistent with responses for another of the Hub's RITLS learning modules 'ProductionWise' where a high proportion of students also had a 'neutral' response (Cosby et al., forthcoming).

There are several ways the practical could be strengthened to ensure a larger proportion of students feel they started to develop the skills to satisfy the communication TLO. An activity that requires students to communicate to the class, or a small group of their peers, how they would communicate to a farmer how to use PA Source, or other farm mapping software to benefit their business is one option. There are numerous examples of possible assessment to achieve this TLO outlined in the "Good Practice Guide: Threshold Learning Outcomes for Agriculture" (Botwright Acuña and Able, 2016). When modifying the practical to strengthen its alignment with the AgLTAS TLOs this document has many annotated resources and case studies which can be used (Botwright Acuña and Able, 2016).

Table 3. Results of initial study looking at student responses to Threshold Learning Outcome questions after completion of PA Source learning module.

Threshold learning outcome questions	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
The practical improved my knowledge of contemporary issues in agriculture.	22.5%	57.7%	14.1%	5.6%	0.0%
The practical explained the role and relevance of agriculture or its related sciences, or agribusiness in society.	14.1%	59.2%	19.7%	7.0%	0.0%
The practical increased my understanding of current opportunities in agriculture to solve dynamic complex problems.	22.5%	53.5%	16.9%	4.2%	2.8%
The practical helped me understand how to select and apply an appropriate tool to solve an agricultural problem	12.7%	52.1%	28.2%	4.2%	2.8%
After completing the practical I am better equipped to communicate with a range of audiences what I learnt.	11.3%	43.7%	40.8%	1.4%	2.8%

Exploring results across student demographics

The previous section of this paper presented the responses of students who completed the survey to a range of questions on employability skills and whether their learning outcomes were achieved. The next part of this paper explores any influence certain demographic factors, such as age, place of residence and degree studied, have on a student's response to certain questions.

It was hypothesised that the age of the student may have an influence on the value they placed on the skills obtained from the PA Source practical on their CV, with an older student, potentially closer to looking for a job paying more attention to this idea. A chi-square test of independence was performed and no statistical difference ($P>0.05$) (Table 4) was found between the age groups and the value score of a CV. As this unit is a first year subject it may be that all students who completed the practical are still too early on in their degree (mature age students present) to be thinking about adding value to their CV. Other demographic factors such as current employment or place of residence may be worth exploring.

Table 4. Age vs practical contributing to increased value of CV

Age (yr)	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	Response Count	p-value
18-21	3.7% (1)	55.6% (15)	37.0% (10)	0.0% (0)	3.7% (1)	27	0.977
22-31	3.9% (1)	57.7% (15)	26.9% (7)	7.7% (2)	3.9% (1)	26	
32-41	7.7% (1)	53.9% (7)	38.5% (5)	0.0% (0)	0.0% (0)	13	
42-51	0.0% (0)	60.0% (3)	20.0% (1)	20.0% (1)	0.0% (0)	5	
Response Count	3	40	23	3	2	71	

It was hypothesised that the type of degree a student is studying would have an impact on whether they believed they would utilise the knowledge developed in this practical in their future employment. A chi-square test of independence was performed and indeed a statistically significant relationship ($P<0.05$) (Table 5) was found between the type of degree a student is studying and the likelihood they will utilise the knowledge in their future employment.

Students studying Agricultural and Rural Science degrees most likely to believe they would use the knowledge derived from the PA Source practical in their future employment with 18.5% strongly agreeing and 81.5% strongly agreeing with the statement (Table 5). This is not surprising as the practical focused on observing data layers that were applicable to an agricultural enterprise (e.g. normalised difference vegetation index, soil apparent electrical conductivity).

One student who was neutral in their response commented that they '*won't be employed in the ag industry*' and another believing it would be '*tricky when I now live in the city*'. A small number of engineering technology students completed the survey but those that did, 33% (3) disagreed, and 11.1% (1) strongly disagreed that they would use the knowledge derived from the practical. It is probable that these students will learn or have already learnt about other mapping software that is more applicable to their future employment. As this practical was taught into a first year introductory subject compulsory for a range of degrees it is difficult to find a tool that all students will find applicable to their future career.

Table 5. Type of degree vs likelihood of using the knowledge developed from this practical in future employment

	Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly	Response count	p-value
Agriculture and Rural Science	18.5% (5)	81.5% (22)	0.0% (0)	0.0% (0)	0.0% (0)	27	0.006
AgBusiness/ AgEconomics	26.7% (4)	46.7% (7)	26.7% (4)	0.0% (0)	0.0% (0)	15	
Engineering Technology	0.0% (0)	33.3% (3)	22.2% (2)	33.3% (3)	11.1% (1)	9	
Environmental Science and Sustainability	11% (2)	56.6% (10)	33.3% (6)	0.0% (0)	0.0% (0)	18	
Other	0.0% (0)	100% (2)	0.0% (0)	0.0% (0)	0.0% (0)	2	
Response count	11	44	12	3	1	71	

The researchers were interested in knowing whether students from rural areas were more likely to them understand how to select and apply an appropriate tool to solve an agricultural problem, if they were already involved in the management of an agricultural enterprise. A chi-square test of independence was performed and no statistical difference ($P>0.05$) (Table 6) was found between a student's place of residence and the understanding they developed as a result of completing the PA Source practical.

Table 6. Place of residence vs increased understanding of how to select and apply an appropriate tool to solve an agricultural problem

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	Response Count	p-value
Rural – living on land/ property	7.7% (2)	53.9% (14)	26.9% (7)	7.7% (2)	3.9% (1)	26	0.58
Rural Town – less than 5,000 people	18.2% (2)	36.4% (4)	45.5% (5)	0% (0)	0% (0)	11	
Town – 5,000-18,000 people	0% (0)	83.3% (10)	16.7% (2)	0% (0)	0% (0)	12	
Major City – 50,000-250,000 people	26.7% (4)	46.7% (7)	26.7% (4)	0% (0)	0% (0)	15	
Capital City – 250,000+ people	14.3% (1)	28.6% (2)	28.6% (2)	14.3% (1)	14.3% (1)	7	
Response Count	9	37	20	3	2	71	

Conclusion

The PA Source module is one of several RITLS learning modules which are available on the Hub. The first cohort of students to evaluate the PA Source practical have indicated that it is meeting its objective of increasing employability skills and graduate knowledge of the latest agri-tech systems. For the series of five TLO questions over 50% of the student cohort who responded to the survey 'agreed' or 'strongly agreed' that the practical had assisted them in achieving the specified learning outcomes. The majority of students also responded positively to the employment questions answering 'strongly agree' or 'agree' to the statements. A statistically significant relationship ($P<0.05$) was found between the type of degree a student is studying and the likelihood they will utilise the knowledge in their future employment.

Continuing the action research cycle, the practical will be improved based on student responses and delivered to a different cohort of students in 2017. Tighter links will made in the learning module to the potential role of this technology in their future careers. The questions of the survey will also be reviewed to ensure they are appropriate for a student who is studying the first or second year of their degree. Answers to questions related to the perception of increased value of their CV and employability may need to be altered or have reference to a student's past or current work experience in the agricultural industry.

One of the questions raised in this research is that students do not know what employers are seeking in a CV. A sub-project of the SmartFarm Learning Hub is to compare the perceived value of CV's of students who have completed learning modules from the Hub and have gained various skills with those that have not (Trotter et al., 2016). This information could be used to assist students in creating a CV that is attractive to employers.

There are numerous other RITLS covering a wide variety of agricultural disciplines in the process of development as part of the SmartFarm Learning Hub project. Selected RITLS will also be transformed as part of the project so they can be taught to high school students as a method of addressing the second objective of the project; engage and encourage students to consider tertiary study and a career in the agricultural industry.

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