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Teachers' perspectives about the content, context, and educational suitability of the GPS cows module for Australian teachers in New South Wales

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Abstract
Technology Mandatory (Tech Mandatory) is a compulsory subject for New South Wales (NSW) Stage 4 students and aims to engage students in production and design activities applicable to Agriculture and Food Technologies (AFT), Digital Technologies (DT), Engineered Systems and Material Technologies. The GPS Cows Module, an agricultural education module focused on livestock and Global Positioning System (GPS) livestock data, was co-designed by the NSW Department of Education and CQUniversity Australia. Teachers had previously expressed concern about being able to successfully teach some content of the Tech Mandatory curriculum's AFT and DT components. Accordingly, the GPS Cows Module focused on livestock production and using digital solutions to address real-world problems. To introduce teachers to the GPS Cows Module and increase Module uptake, several one-day professional learning workshops were run in 2018 and 2019 across NSW, Australia. A post-workshop survey was used to evaluate the GPS Cows Module and the suitability of content related to AFT and DT learning outcomes. Participants agreed or strongly agreed that the Module content would address some of the AFT (92.8% combined) and DT (95.5% combined) outcomes of the curriculum. Over 72% of participants felt their students would find GPS Cows engaging and were excited to teach the Module. However, there were some barriers to implementation including perceptions of student ability, access to technology, teacher confidence and time. Overall, the GPS Cows Module comprises of high-quality content to address some of the AFT and DT outcomes of the Tech Mandatory curriculum. Additionally, it reinforces the importance of authentic data, real-life case studies, and a variety of accompanying resources to effectively implement into a teaching program.

Keywords Agricultural technologies · Agri-tech education · Authentic data · Co-developed learning modules · High school teachers · Online learning

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Introduction

Design and technologies education is now considered integral to general education in countries across the world. In the compulsory years of schooling, teachers are continuously challenged to interpret national curriculum frameworks that mandate such integration. This challenge is further compounded when within countries, different jurisdictions mandate subject-level interpretations to which teachers must comply. The conundrum for teachers is that they may not have been prepared for the integrated content and pedagogical demands of such subjects. This paper responds to that challenge through its report of findings from a nationally framed, state jurisdiction interpretation of an integrated design and technologies initiative for Australian middle years schooling.

The Australian Curriculum Assessment and Reporting Authority (ACARA) was established in 2009 to deliver a national curriculum to all schools. As an independent statutory authority, ACARA developed the national curriculum as a way of creating uniformity of education across Australia (ACARA, 2020; Turner & Cameron, 2018), though implementation of the curriculum is still the responsibility of states and territories. In New South Wales (NSW), the Australian Curriculum is used as a common foundation for the development of courses. However, the state maintains the flexibility to modify syllabus content to suit the NSW examination system (NESA, 2021a). In NSW secondary schools, agriculture is taught as a unit under the compulsory 'Technology Mandatory' (Tech Mandatory) subject for Stage 4 (Years 7—8) (NESA, 2017). Elective subjects such as 'Agricultural Technology' and 'Agriculture' may also be taught in Stages 4 and 5 (Years 7—10) and Stage 6 (Years 11—12), respectively.

As previously mentioned, Tech Mandatory is a compulsory component of the Stage 4 curriculum in NSW. The subject aims to engage students in production and design activities through the practical application of knowledge in Agriculture and Food Technologies (AFT), Digital Technologies (DT), Engineered Systems and Material Technologies (NESA, 2017). The agriculture portion of the syllabus concentrates on managed environments such as farms or plantations, with students learning about the process of food and fibre production, including innovative and sustainable supply of materials. Although the teaching of the agriculture component is mandatory, it comprises only a small portion of the overall subject; through an indicative 150 h to be shared between AFT, DT, Engineered Systems and Material Technologies over two years (NESA, 2017).

As stated in Meischen and Trexler (2003), to be accurately informed about agriculture requires "*knowledge and understanding of agriculturally related scientific and technologically-based concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity*" (p. 44). Agricultural technology, or 'agri-tech' encompasses precision agriculture which utilises technological innovations to improve productivity, profitability, efficiency and support management decisions across the agricultural supply chain (International Society of Precision Agriculture, n.d.). To support these growing innovations, demand for technology-related skills and agricultural knowledge is likely to increase in the future and thus, attraction of highly skilled workers into the industry is essential. However, there is currently a skills shortage in the agricultural industry with the demand for employees outstripping supply (Pratley, 2017). According to Wu et al. (2019), highlighting the advances in agriculture technology, innovation and entrepreneurship, could potentially bring young Australians into the industry. Inclusion of agriculture in the school curriculum is also important to

increase awareness and encourage interest (Awal et al., 2012) and needs to focus on the emerging skills that are necessary to succeed in the sector.

Teaching out of field is a common solution to address the shortage of qualified teachers in many subject areas, including agriculture and digital technologies. In Australia, approximately 26% of teachers for Years 7—10 and 15% of teachers for Years 11—12 are teaching in subjects that they are not specialised in (Weldon, 2016). As a result, teachers often struggle to incorporate agriculture and digital technologies into their teaching programs. In research by Johnson et al. (2016), these struggles can be grouped into three main areas: access, training, and support constraints. Access constraints refer to having access to the reliable hardware, software and internet connection required for teaching. Training constraints refer to inadequate professional development and guidance of the teacher, leading to lower confidence and inclination to incorporate new technology. Finally, support constraints in the form of a lack of assistance from technology creators or other colleagues may also impact uptake. As technology continues to develop at a rapid rate, teachers are expected to stay up to date with the latest trends and developments (Wood et al., 2005). This may be particularly difficult if the teachers are not provided with either the training resources and/or time or opportunities for high-quality professional development. In the context of agriculture, the rate of agri-tech development represents a complex industry undergoing significant technological change. This presents teachers with the opportunity to introduce students to novel and interesting technologies, particularly if they align with existing curricula such as Tech Mandatory. However, to ensure students can achieve the required learning outcomes, it is crucial that adequate support, in the form of high-quality professional development, resources and tools, are provided for teachers.

Several resources focused on agriculture exist to assist teachers in the development of meaningful education programs. Sample units can be found on the NSW Education Standards Authority website (NESA, 2021b) and include mapping to specific curriculum content and outcomes with suggested options for formal and informal assessment. Resources may also be offered by other government bodies, including the NSW Department of Primary Industries (NSW Department of Primary Industries, 2021) and cover a broad range of topics for Stages 4—6, including livestock, aquaculture and grain production. Other organisations, including the Royal Agricultural Society of NSW (Royal Agricultural Society of NSW, 2021) and Meat and Livestock Australia (Meat and Livestock Australia, 2020) also offer numerous resources for primary and secondary students. Although many resources exist, there is a limited number that incorporate agri-tech or provide an opportunity to interact with authentic data. Given the impact of emerging technologies on the industry, there is a clear opportunity to develop school-based programs that help to address this gap by providing students with digital technology skills to allow them to meet learning outcomes in agriculture at the same time.

The GPS Cows Module is an agricultural education resource that introduces students to the concept of precision livestock tracking using Global Positioning System (GPS) technologies (GPS Cows, 2020). Co-designed by the NSW Department of Education and CQUniversity Australia, the Module provides content that aligns with the six most relevant content descriptors required for the Tech Mandatory AFT and DT learning outcomes. The Module can be taught over approximately 25 h over a 10-week period and all resources are provided to teachers, including free access to the ArcGIS software (ESRI, 2016) and a research grade GPS livestock tracking collar for schools with access to animals. For those schools with no livestock, sample datasets from a commercial farm are provided. To facilitate Module uptake, a one-day professional learning workshop was provided to teachers across the state. This paper engages with the perspectives of these workshop participants,

with the aim of determining teachers' perspectives about the content, context, and educational suitability of the GPS Cows Module for Tech Mandatory teachers in NSW. Specifically, perspectives regarding whether the Module content satisfies some of the AFT and DT components of the NSW Tech Mandatory curriculum were gathered, and if Module application can help teachers to assess student achievement of the required learning outcomes.

Materials and methods

This paper engages with two component parts of GPS Cows; the Module itself, which constitutes the agricultural education resource, and the professional learning workshop, including its content and activities. Details of the GPS Cows Module and workshop are provided in Sect. "The GPS Cows Module" and Sect. "Professional learning workshop", respectively.

The GPS cows module

The GPS Cows Module focuses on supporting students to develop skills and knowledge in a range of topics covered in the AFT and DT components of the Tech Mandatory curriculum (Table 1) (GPS Cows, 2020; NESA, 2017).

An introduction to GPS

The Module commences by outlining the application of GPS using everyday life, sport, military and pet examples. A brainstorming activity enables students to consider what it would have been like navigating before GPS. The history of GPS is also explored, with a particular focus on the science and mathematics used to make it operate. To examine the process of GPS data transmission, activities involving the comprehension of wave properties (amplitude, wavelength, frequency), understanding of the differences between digital and analogue data and how digital data is transported are also explored.

Technology advances in livestock production

Next, the importance of agriculture in terms of food and fibre production, and the fiscal impact on the Australian economy is discussed. Technological advances and the application of these in the livestock industry are showcased including the use of Radio Frequency Identification Devices (RFID) for individual identification of animals, livestock weighing systems and the use of tracking technologies such as GPS. As the Module uses livestock as the case study, normal behaviours displayed by grazing animals such as grazing, drinking, walking, and resting are discussed to allow contextualisation of the data.

How to collect your own animal location data

A variety of case studies using authentic data are presented to highlight the numerous applications of livestock tracking technology on Australian farms and encourage consideration of how animal location and behaviour data could be collected and analysed. A case study farm, 'The Plateau', is introduced and a sample dataset is supplied to reduce the barrier of needing a school farm or livestock to implement the Module. This also ensures that

Table 1 Alignment of the GPS Cows Module content compared to the Stage 4 tech mandatory curriculum content for agriculture and food technologies (AFT) and digital technologies (DT) components (GPS Cows, 2020; NESA, 2017)

Curriculum content		GPS Cows content			
		Background information	Technology advances in livestock production	How to collect your own animal location data	Analysing and interpreting data in ArcGIS Online and Microsoft Excel
AFT content	Investigate the importance of food and fibre production to Australia's food security and economy including Asia's imports and exports	✓	✓		
	Investigate how food and fibre production is managed in environments as a system and how sustainability can be improved		✓	✓	✓
	Develop criteria to evaluate design ideas, processes and solutions, the functionality, aesthetics and a range of constraints				✓
	Acquire and interpret data			✓	✓
	Produce and implement an agricultural project and/or produce nutritious food				✓
	Select, justify and use a range of appropriate tools and techniques in an agricultural project and/or food preparation				✓

Table 1 (continued)

Curriculum content		GPS Cows content			
		Background information	Technology advances in livestock production	How to collect your own animal location data	Analysing and interpreting data in ArcGIS Online and Microsoft Excel
DT content	Evaluate how existing information systems meet needs, are innovative, and take account of future risks and sustainability	✓			
	Define and decompose real-world problems, taking into account functional requirements and a range of constraints, e.g., economic, environmental, social, technical and usability	✓	✓	✓	
	Plan and manage projects individually and collaboratively			✓	
	Collect and access data from a range of sources				✓
	Evaluate the authenticity, accuracy and timeliness of data				✓
	Interpret and visualise data using a range of software to create information		✓		✓

correct answers can be provided to alleviate teacher concerns about whether their students are undertaking the analysis correctly. There is also an opportunity to analyse data collected from school livestock (or any other animals that can be accessed) in addition to the 'The Plateau' dataset, with information on how to configure, attach and download their own GPS tracking collar data.

Analysing and interpreting data in ArcGIS online and microsoft excel

By partnering with ESRI®, a GIS software company, free access to ArcGIS Online® is given to all secondary schools participating in the Module. As such, most of the Module content is dedicated to data analysis and interpretation activities using both ArcGIS Online® and Microsoft Excel. This provides an opportunity to develop digital literacy and allows for exposure to software which is utilised in several employment situations. Data analysis and interpretation activities include investigating GPS error and key animal welfare, productivity and profitability indicators such as how animals utilise their surrounding environment (paddock utilisation) and access water (water visitation). Finally, further data analysis skills are developed using Microsoft Excel to interpret interactions between livestock tracking data and weather including how to create column graphs and pivot tables.

Types of resources in the GPS cows module

In developing the Module, it was recognised that typically resources available to teachers are text heavy and do not account for different learning styles of students. The type of resources created for the Module deliberately encompass an extensive range of video resources, discussion questions, quizzes, use of readily available apps, several software programs and authentic case study data to increase engagement and support learning. For each Microsoft Excel or ArcGIS Online® activity, accompanying screenshots and how-to-videos were created to cater for different learning styles and computer proficiency. Readily available augmented reality apps ('GNSS View'—an app to view different satellite positioning systems (GNSS View, 2016)) provide an additional way to introduce new content and terminology such as what GPS is and how it works. The inclusion of authentic data was an important consideration when developing GPS Cows as teachers anecdotally indicated to the development team this was hard to access. Consequently, real-life case studies and farmers were utilised to enable specific issues and applications to be highlighted e.g., GPS animal tracking for targeted fertiliser management and stock theft.

Professional learning workshop

To support Module uptake and provide teachers with the requisite training required to incorporate the Module into their teaching program, a one-day professional learning workshop was developed. This workshop was presented at 16 locations across metropolitan and rural NSW (Australia) in 2018 and 2019 and were open to all NSW secondary teachers from government schools free of charge. Teachers from Independent and Catholic schools were also able to participate for a nominal fee of $100. The workshop is a condensed version of the GPS Cows Module. Details of the workshop and included activities is detailed in Manning et al. (2022). The aim of the workshop was to upskill teachers in the implementation of GPS Cows and provide the background knowledge required to effectively teach the content in their classroom.

Data collection and analysis

The data presented in this paper was collected by a post-workshop survey. The survey questions were co-designed with NSW Department of Education Technological and Applied Studies Advisors and the research team. Internal validity was assessed by testing the content of the questions (Roberts & Priest, 2006) with participants of a pilot workshop comprising of Stage 4 Tech Mandatory teachers from various backgrounds and experience levels. Good internal consistency reliability was demonstrated ($\alpha = 0.9$), using IBM SPSS Statistics for Windows (IBM Corp, 2020).

Hosted on SurveyMonkey™, the survey was emailed to all participants following workshop completion. Both closed- (n = 21) and open-ended (n = 4) questions were asked. Closed-ended questions encompassed demographic information (e.g., teaching experience, gender, formal qualifications) and general evaluation questions. These questions were generally answered under given categories (for the demographic data) or on a 5-point Likert scale (for the evaluation data). Additionally, for the question which asked about the use of the Module to address aspects of the curriculum, respondents were asked to rate the applicability on a 10-point scale (1—not at all [applicable]; 10—completely [applicable]). This was then analysed using descriptive statistics.

Open-ended questions allowed participants to comment on the challenges and barriers of implementing GPS Cows into teaching programs, with a thematic analysis undertaken to present results. This process followed methodologies of Braun and Clarke (2006), including familiarisation with the data, generating initial broad themes, reviewing themes and amalgamating common themes as necessary. Themes were discussed with the wider authorship team prior to analysis. All research was approved by the CQUniversity Australia Human Research Ethics Committee (approval number 21324).

Results

Demographics of teacher participants

There were 185 teachers who completed the post-workshop survey in 2018 and 2019. For the complete survey, the average response rate per question was 94.5% (standard deviation: 0.09; range: 63.2%—100%). Key demographics are presented in Table 2, including a comparison between the sample population and the broader NSW teacher population.

Evaluation of the GPS cows module content and alignment to the stage 4 technology mandatory curriculum

Participants mostly agreed (53.4%; n = 94) or strongly agreed (42.1%; n = 74) that the content of the GPS Cows Module would address some of the DT outcomes of the Tech Mandatory curriculum (Fig. 1). Similarly, participants mostly agreed (56.7%; n = 102) or strongly agreed (36.1%; n = 65) that the Module would address some of the AFT outcomes of the Tech Mandatory curriculum (Fig. 1). Participants were generally confident that they could use the Module as part of their teaching program to enable students to achieve the required outcomes (55.7% agree (n = 98); 30.7% strongly agree (n = 54)).

Table 2 Key demographics for workshop participants. Data presented as a total number of responses (count) and percentage. Available statistics for NSW teachers are also shown

Demographics	Response	Count	Percentage (%)	NSW statistics
Gender	Male	71	38.6	27.6[1]
	Female	113	61.4	72.4[1]
	Other	0	0.0	Not recorded
Teaching experience	Less than 1 year	4	2.2	30.0 (5 years or less)[2]
	1—3 years	17	9.3	
	4—7 years	24	13.1	16.4 (6—10 years)[2]
	8—10 years	22	12.0	
	10—15 years	42	23.0	15.7 (11—15 years)[2]
	16 + years	74	40.4	37.8[2]
Formal qualification in agriculture	University—postgraduate	27	14.6	Not available
	University—undergraduate	58	31.4	
	Diploma	7	3.8	
	TAFE certificate	10	5.4	
	No agricultural qualification	83	44.9	
Current school location	Rural Town—less than 5,000 people	52	28.3	Approximately 25% of NSW teachers are in rural or remote locations[3] (Defined as any region outside of Sydney metropolitan area, Newcastle, Wollongong and the NSW Central Coast)
	Town—5,000–18,000 people	37	20.1	
	Large Town—19,000—49,000 people	54	29.3	
	Major City—50,000–250,000 people	23	12.5	
	Capital City—250,000 + people	18	9.8	

[1]NSW Department of Education (2020)

[2]NSW Department of Education (2016)

[3]Mazurski et al. (2016)

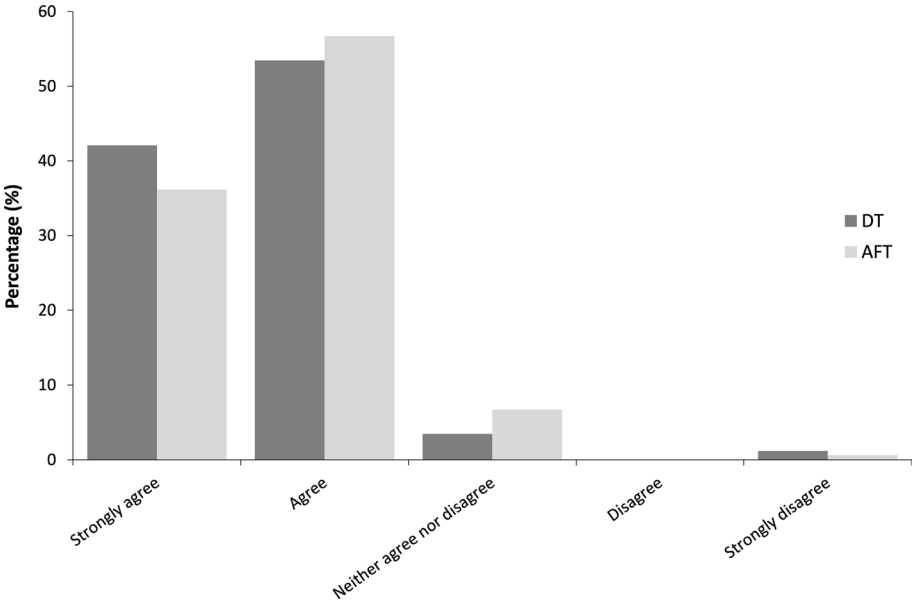

Fig. 1 Participant satisfaction of the GPS Cows Module content for students to develop some of the knowledge and understanding of DT (dark grey) and AFT (light grey) learning outcomes as required by the Stage 4 Tech Mandatory curriculum

An evaluation of the GPS Cows Module content to address specific AFT and DT learning outcomes is presented in Table 3. To understand this, participants were asked out of 10 (1—not at all, 10—completely) whether the Module would allow students to be assessed for achievement of each learning outcome. The 'acquiring and interpreting data' (AFT) outcome recorded the highest mean score (8.3). Following this, the 'collection and access of data from a range of sources' (DT), 'interpretation and visualisation of data using a range of software to create information' (DT) and 'evaluation of the authenticity, accuracy and timeliness of data' (DT) outcomes scored 8.2, 8.1 and 8.0, respectively. The lowest mean score of 6.8 was recorded for the 'importance of food and fibre production to Australia's food security and economy including Asia's imports and exports' (AFT) outcome.

Participants were also asked a series of statements relating to more general evaluation of the Module and the use of the Module to improve digital literacy skills. These were scored on a scale of 1—5 (1—strongly disagree, 5—strongly agree). Mean scores for each statement are presented in Table 4. As shown, the statement 'analysing authentic data improves a student's learning experience' had the highest mean score (4.4 out of 5). Following this, the statement that '[GPS Cows] will increase the digital literacy skills of students' had a mean score of 4.3. Potential issues to be considered when implementing the Module included '…access to required computer equipment' and '… sufficient internet connectivity', with mean scores of 3.9 and 4.0, respectively. When asked for any additional comments, one participant stated that the Module "*improves relevance and engagement with data*" and another that "*there is potential for students to gain knowledge and understanding both in an agriculture and digital setting*". However, one participant did state that "*computer access [is strong] at school but internet*

Table 3 Evaluation of the GPS cows module content compared to tech mandatory curriculum content for agriculture and food technologies (AFT) and digital technologies (DT)

	Curriculum content	Mean score (out of 10)
AFT	Investigate the importance of food and fibre production to Australia's food security and economy including Asia's imports and exports	6.8
	Investigate how food and fibre production is managed in environments as a system and how sustainability can be improved	7.6
	Develop criteria to evaluate design ideas, processes and solutions, the functionality, aesthetics and a range of constraints	7.1
	Acquire and interpret data	8.3
	Produce and implement an agricultural project and/or produce nutritious food	7.1
	Select, justify and use a range of appropriate tools and techniques in an agricultural project and/or food preparation	7.4
DT	Evaluate how existing information systems meet needs, are innovative, and take account of future risks and sustainability	7.6
	Define and decompose real-world problems, taking into account functional requirements and a range of constraints, e.g., economic, environmental, social, technical and usability	7.7
	Plan and manage projects individually and collaboratively	7.4
	Collect and access data from a range of sources	8.2
	Evaluate the authenticity, accuracy and timeliness of data	8.0
	Interpret and visualise data using a range of software to create information	8.1

Table 4 General evaluation of the GPS Cows Module content and the use to the Module to improve digital literacy skills (ranked from 1—strongly disagree to 5—strongly agree)

Statement	Mean score (out of 5)
I now have the required background/introductory resources needed to teach this to my class	4.1
I am satisfied this material will allow students to develop some of the knowledge and understanding of agriculture and food technologies as required by the Stage 4 curriculum	4.2
My students would have access to the required computer equipment needed to complete the practical	3.9
My students would have access to sufficient internet connectivity to complete the practical	4.0
This practical will increase the digital literacy skills of my students	4.3
Analysing authentic data improves a student's learning experience	4.4

access at home … is problematic/limited due to our rural setting". This was reiterated by another participant, noting "*access to technology is my only concern*". One participant did state that they were "*concerned [that] students with lower learning abilities will find this too challenging*".

When asked whether participants had any other comments about the Module, 51.3% had a positive remark, including comments that the Module was an "*excellent initiative*", "*great resource*", "[a] *great hands-on project learning for students*" and assisted them "*both personally as a farmer and as a Stage 4 Technology Mandatory teacher*". Nearly 37% of participants had no additional comments (34.2%) or the comment was not relevant to Module evaluation (2.6%). The remaining participants had either neutral (6.0%) or negative comments (6.0%), including "*student engagement may be an issue*" and "*individual students have different technical problems and literacy [skills]*". There were no comments regarding the inadequacy of the Module to meet curriculum outcomes. Major themes are presented in Table 5.

Table 5 Major themes of the comments presented as a percentage of total number of comments (n = 117)

Theme	Pos[a]	Neu[a]	Neg[a]	NC/NR[b]	Total (%)
General positive comment	31.6	–	–	–	31.6
Workshop/presentation	10.3	–	2.6	–	12.8
Resource	7.7	–	–	–	7.7
Concerns regarding complexity of the Module or student engagement	–	3.4	2.6	–	6.0
Further module development required	–	2.6	0.9	–	3.4
Understanding of real-world implications	1.7	–	–	–	1.7
No Comment/ Comment not relevant	–	–	–	34.2/2.6	36.8
Total	51.3	6.0	6.1	36.8	100

Sixty-eight participants did not answer this question (not shown)

[a]Comments provided in a positive (pos) context, neutral (neu) or negative (neg) context

[b]NC: No comment; NR: Non-relevant comment

Table 6 Major challenges and barriers of implementing the GPS cows module into teaching programs

Theme	Total (%)
Perceived student ability	30.5
Access to technology (computers/resources)	13.9
Teacher confidence	6.0
Lack of student interest	6.0
Internet access (speed & reliability)	4.6
Time	2.6
Access to animals for data collection	2.6
No comment or not sure	29.8

Values represent the percentage of the total number of comments (n = 151). Thirty-five participants skipped this question (data not shown)

Challenges and barriers to implementation

Barriers to implementation in each participant's teaching programs were centred around student ability and interest, access to technology, teacher confidence and time (Table 6). Internet accessibility in terms of reliability and speed was also highlighted as a barrier. Furthermore, concerns around student ability to use and handle data in Microsoft Excel was commonly identified. Finally, challenges in terms of access to animals for data collection were acknowledged, although this is not actually a requirement to complete the Module.

Discussion

This paper presents teachers' perspectives about the content, context, and educational suitability of the GPS Cows Module for Tech Mandatory teachers in NSW. Overall, teachers appear satisfied that the Module successfully supports achievement of AFT and DT learning outcomes. The importance of resources which allow students to interact with authentic data from an economically important sector such as agriculture was also reinforced.

Benefits of co-developed modules for authentic learning experiences

This research has shown that the GPS Cows Module provides sufficient content to assist student understanding of some AFT and DT components of the Stage 4 Tech Mandatory curriculum (Table 3; Fig. 1). However, it is not enough to simply supply content resources to teachers, they also need to be of high-quality. According to the NSW Department of Education (2021), "*school staff [should] exercise professional judgement… about the suitability of teaching and learning resources to support curriculum implementation*" (How to evaluate resources section). To support this, a resource evaluation tool is provided by the Department, consisting of a check-box activity covering a variety of questions. In this case, it appears the onus is on the teacher to evaluate the resource, rather than the resource-developer being responsible for producing a quality product. This highlights a clear limitation in the use of external resources. When evaluating a resource, two main questions that NSW teachers are expected to answer include: (i) is the resource relevant to the curriculum

and supports achievement of NSW syllabus outcomes; and (ii) does the resource comply with relevant NSW Department of Education policies and procedures (NSW Department of Education, 2021). In the case of GPS Cows, the Module was developed in conjunction with the NSW Department of Education. Therefore, it can be safely assumed that the content is of high quality and compliant with the NSW curriculum, policies, and procedures. In addition to development with the Department, the Module has also been evaluated by teachers through a pilot program (Cosby, Trotter, et al., 2019). Outcomes from this highlighted the need for high quality resources and ongoing support to enable success of implementation. Since this pilot, the team has further developed the resources. The results of the current paper will also be used for further refinement of the GPS Cows Module moving forward.

Authentic data

Authentic data refers to true quantitative or qualitative information, generally collected from real-life situations (Kjelvik & Schultheis, 2019). Authentic data is usually generated through measurement tools or automated sensors, and generally contains outliers and/or noise. In contrast, inauthentic data is usually synthetic or manipulated data that is generated to demonstrate a particular result or pattern. The use of authentic data in the classroom provides real-world context and allows students to understand the practical application of knowledge (Kjelvik & Schultheis, 2019). In addition, authentic data is generally more engaging for students (Schultheis & Kjelvik, 2015) and have been shown necessary for them to consider further learning or potential career options (Spuck, 2014). Finally, authentic data is usually more complex than inauthentic data. In research by Kerlin et al. (2010), students that utilised complex data were more likely to identify patterns and make predictions using the data, and more commonly evaluated and debated conclusions with their classmates. However, whilst authentic data enables improved student connection, data complexity needs to be carefully curated to ensure students are not overwhelmed by the task at hand (Kjelvik & Schultheis, 2019).

The GPS Cows Module provides students with access to authentic data in the form of various case studies that highlight the numerous applications of livestock tracking technology on Australian farms. For schools without access to livestock, a sample dataset from a case study farm is provided for all activities. For those with livestock access, students are encouraged to develop their own scientific research questions and collect the appropriate data. In this study, the use of authentic data was favoured, with most agreeing that the use of authentic data improved the student's learning experience (4.4 out of 5). Participants also agreed that the Module will increase the digital literacy skills of students (4.3 out of 5), although concerns about data complexity were noted.

Data and future employability

As we continue through the digital age and our reliance on 'big data' grows, the need for employee data literacy increases (Gibson & Mourad, 2018). This is also true for agriculture, with the number of agri-tech tools and systems becoming more prevalent in commercial systems. To ensure students are best placed for entry into the workforce, it is crucial that students are introduced to sound data science principles at school. This is mirrored in the workforce, with continued growth in Australia's digital economy resulting in increased demand for data science skills (Deloitte Access Economics, 2018). In a report by the

Australian Industry Group (2017), strengthening of school-industry partnerships was found to advance secondary school student participation in STEM disciplines. The report also noted that from an industry perspective, skill development is just as important as academic knowledge and should be reflected in school curricula. In the case of the GPS Cows Module, students are not only introduced to real-life case studies and authentic data, but they are also given the opportunity to interact with commercial programs and systems such as ArcGIS Online® which are used in many workplaces. This opportunity provided hands-on opportunities for students to gain skills to use in their future employment and reinforced the range of digital platforms which can be applied to solve problem in the agricultural industry.

Types of resources to facilitate learning

According to Jeong and Hmelo-Silver (2010), learning resources are "*information or tools that can be used to assist learners in the process of locating, recording, and further processing of the learning materials*" (p. 84). They may be static (e.g., printed resources) or dynamic (e.g., continually updated datasets). Learning resources may also differ in their function; for example, information repositories (i.e., textbooks, videos) or cognitive tools (i.e., calculators or visual guides). The GPS Cows Module utilises an extensive range of learning and video resources, including case studies, discussion questions, quizzes, readily available apps, several software programs, and authentic datasets.

Although learning resources are useful for improving and deepening student understanding, the application of resources faces some challenges (Jeong & Hmelo-Silver, 2010). For example, difficulties in locating relevant information (McCrory Wallace et al., 2000) or a general reluctance to utilise the resource (Cramer et al., 2007). Difficulties in using the resources is also common, with Jeong and Hmelo-Silver (2010) finding that students, particularly lower-achieving students, may need guidance on how to use the resource effectively. For the GPS Cows Module, students are provided with a comprehensive guide on how to use the data, with tasks increasing in complexity as student skill levels grow. The use of the professional development workshops to support incorporation into their individual teaching programs is also beneficial, improving teacher confidence and ability to lead data-driven classroom discussions (Kjelvik & Schultheis, 2019).

Another consideration in the generation of learning resources is their suitability for use in diverse classroom settings. Learning styles refer to the cognitive, emotional, and physiological features that impact how a student understands concepts and interacts in the learning environment (Khamparia & Pandey, 2020). A variety of learning styles theories have been developed, e.g., VAK learning styles which divides students into visual, auditory and kinaesthetic learners (University of Massachusetts, 2021). These styles can significantly impact student learning and should be considered during resource development (Khamparia & Pandey, 2020; Lecky et al., 2011). This has been addressed through the development of the Module, with varied resources that encourage self-led reading, group discussion, problem solving and trial-and-error. This allows flexible and adaptive application to enhance student learning.

Barriers perceived by teachers to implementing the GPS cows module

Barriers for Module implementation are shown in Table 6 and are generally centred around computer and internet access, or rather lack thereof. This has also been identified by Cosby,

Manning et al. (2019), where insufficient internet connectivity and computer resources was considered a barrier to properly implementing learning materials focussed on agricultural concepts. In the current study, many teachers also identified digital literacy and technical skills, including the use of Microsoft Excel, as a barrier. Being an online module, access to computer resources and reliable internet is necessary for delivery. This may be compounded by student and/or school location or socio-economic status. In Australia, regional and rural areas have been found to have significantly lower rates of broadband access compared to urban areas (Australian Commonwealth Government, 2021). In addition, research by Curtin (2001) found that household income can impact internet access, citing high cost of the service as a commonly identified limitation. When it comes to the identified barriers of low digital literacy and technical skills, this may expose the clear need for modules such as GPS Cows, which focus on educating students on the use of agri-tech, and by extension, technology in general. This is highlighted in Table 3, where the Module's applicability to outcomes such as 'collect and access data from a range of sources', 'interpret and visualise data … to create information' and 'acquire and interpret data' were given mean scores of 8.2, 8.1 and 8.3 out of 10, respectively. Thus, while some level of digital literacy is expected prior to commencing GPS Cows, it is also anticipated that the Module will assist in student skill and knowledge development in this area. Furthermore, given the rising dominance of digital and technical skills in many career paths, including agriculture (Skills Impact, 2019; Wu et al., 2019), it is important for students to develop their proficiency prior to entry to the workforce.

Another barrier of implementing the GPS Cows Module is 'time'. In this case, it is unclear if this relates to the time required for teachers to develop the confidence and skills required to teach this Module, or the time to implement GPS Cows in the classroom. For the former, when asked if they had the required background and introductory resources needed to teach GPS Cows, participants scored the Module an average of 4.1 out of 5 (Table 4). Thus, it appears that the training provided through the workshop should be sufficient to prepare teachers for the implementation of the GPS Cows Module, and therefore significant additional preparation time is avoidable. If instead the identification of 'time' relates to the time required for implementation in the classroom, the Module has been developed as an entire unit of work and provides an indicative 25 h of content to be taught over a 10-week period. Given the strong alignment of the content to support teaching of AFT and DT outcomes (Tables 1; 3), implementation of the Module could be considered a worthwhile time investment, particularly given that all Module resources are provided free of charge. In previous research of the pilot GPS Cows Module (Cosby, Trotter, et al., 2019), preparation time was identified as a barrier to implementation, particularly for those teachers who manage a school farm. Teacher time was also identified as the second largest barrier to increasing food and fibre concepts in teaching programs in Cosby, Manning et al. (2019), again highlighting the benefit of providing all the required resources to teachers as part of the Module development.

Related to the issue of time, resources, including access to animals for data collection was also identified as a further barrier for implementation. However, as previously mentioned, all required resources are provided to participating schools. In addition, access to animals for data collection is not actually a requirement as sample datasets are available for schools that do not have access to animals. In addition, students can track their own movements using Map My Tracks (mapmytracks.com) and use this for analysis following the instructions provided. Financial resources are also another limitation identified in previous research (Cosby, Manning, et al., 2019). In the case of the GPS Cows Module, ArcGIS Online® is provided free of charge to all participating secondary schools. This significantly

reduces the financial burden on schools, resulting in a reliable and economically sustainable resource (Cosby, Trotter, et al., 2019).

Conclusion

In the case of the GPS Cows Module, a complete agricultural education resource that introduces students to the concept of precision livestock tracking using GPS, use of authentic data and an extensive range of learning, video, interactive and case study resources enable teachers to confidently support students to achieve some learning outcomes of both the AFT and DT components of the Stage 4 NSW Tech Mandatory curriculum. Though there was a need for continued professional development opportunities and ongoing support to ensure GPS Cows implementation into teaching programs is successful, this research presents an overall positive view of the Module and provides guidance for the future development of teaching resources to assist teachers in delivering national curriculum requirements.

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Data availability The datasets generated and/or analysed during the current study are not publicly available due to the potential to indirectly identify individual study participants based on a combination of demographic characteristics and location data. However, select subsets of data are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors declare that they have no competing interests.

Ethics approval All research was approved by the CQUniversity Australia Human Research Ethics Committee (approval number 21324).

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