Department of Primary Industries

Farming for the 21st Century

Supporting document

NSW DPI Schools Program

www.dpi.nsw.gov.au

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Contents

Farming for the 21st Century Overview

An HSC Elective

Farming for the 21st Century is one of three electives offered in the NSW Agriculture Stage 6 Syllabus.

It aims to highlight the range of developing technologies which are helping to transform agricultural management and production. Students have the opportunity to study a range of technologies and analyse their impact on agricultural industries.

This document provides teachers and students with links to a number of resources and activities that align to the Farming for the 21st Century syllabus outcomes and dot points to support their learning throughout this elective. This supporting document has been developed as a digital resource and to access the large number of hyperlinks which it contains it must be used in this format.

Past questions and sample answers

Teachers, students and markers are able to view past HSC examinations and Sample HSC Examination Questions on the NSW Board of Studies, Teaching and Educational Standards website.

Sample answers are sometimes provided with past HSC papers and provide excellent examples of how to address the marking guidelines for each question. It should be noted that these sample answers are not necessarily the very best answer, nor are they the only possible answers.

Innovation, ethics and current issues

1. Issues relating to research and development

SYLLABUS POINT

Discuss issues related to the research and development of technologies including funding sources, patents, plant breeders' rights, animal welfare, legislation and contracts.

Funding sources

Agricultural research and development (R&D) aims to address priority industry needs and develop a more productive, profitable, competitive and sustainable agriculture industry. Funding for R&D is available through the public sector (government) or private sector (industry and business).

Public funding

R&D priorities for public funding are set out in the Industry Strategic Plans developed by industry and led by their Commodity Councils and the National Primary Industries Research, Development and Extension Framework (RD&E).

From these Industry Plans and the RD&E Framework, Rural Research and Development Corporations (RDCs) and Cooperative Research Centres (CRCs) develop their strategic and operational directions. RDCs are the main way the Australian government and primary producers co-invest in R&D for industry and community benefits, while CRCs enhance research collaboration between research bodies. RDCs and CRCs contract research, on a project basis, to research bodies such as State Government departments, CSIRO, universities and private providers.

Elizabeth Webster's The Conversation article Rural Australia has innovation lessons to teach us all (2014) provides a good overview of RDCs and R&D funding in Australian primary industries.

Funding for R&D can be difficult to attain as research and development proposals must align with appropriate strategic plan/s to be considered for public funding. Governments, university agriculture faculties and research institutes are all under funding pressure which also impacts on the funding available to R&D.

Private funding

Privately owned and operated enterprises, often large multi-national corporations, also undertake research in agricultural pursuits. R&D in this realm is often more commercially focused with the intention of developing adoptable products for economic gain. An example of privately funded R&D is FarmLink, a cooperative R&D fund which aims to give growers the power to influence research priorities and be actively involved in the research process.

Private funding is often dependent on the economic viability or benefit of the research project being evident prior to R&D being undertaken.

Patents

"A patent is a right that is granted for any device, substance, method or process that is new, inventive, and useful. A patent is legally enforceable and gives you (the owner), exclusive rights to commercially exploit the invention for the life of the patent" (IP Australia, Australian Government*). Patents help protect R&D investment and ensure the legal and economic viability of R&D.

The Patents section of the IP Australia, Australian Government website provides a wealth of information about patents including case studies which provide examples of the ways patents protect and enhance research and development.

*IP Australia is the Australian Government agency that administers intellectual property (IP) rights and legislation relating to patents, trademarks, designs and plant breeder's rights.

Plant breeders' rights

"Plant Breeder's Rights (PBR) are used to protect new varieties of plants that are distinct, uniform and stable. A PBR is legally enforceable and gives you, the owner, exclusive rights to commercially use it, sell it, direct the production, sale and distribution of it, and receive royalties from the sale of plants." (IP Australia, Australian Government).

PBRs, like patents, protect investment in R&D by ensuring the economic value of plant breeding R&D.

IP Australia, Australian Government, provide a range of information on Plant Breeder's Rights on their website. Their FAQs section may be particularly useful to identifying how PBRs will affect and protect research and development.

Animal welfare

The Australian agriculture industry is committed to animal welfare in the production of agricultural commodities. This commitment extends to the welfare of animals in R&D activities. R&D which requires the use of animals must be rigorously planned to manage the welfare of animals.

The Animals in Research and Teaching (ART) component of the Australian Animal Welfare Strategy provides up-to-date information on the ART working group and projects.

Animals in Schools website provides information for schools on the keeping, use and management of animals in schools to satisfy animal welfare requirements.

Australian Government Department of Agriculture and Water Resources Animal Welfare webpage provides a range of information and documents to support responsible animal welfare.

Legislation

Government legislation can impact on R&D and influence what is researched, how it is researched and why it is researched.

Legislation directly impacts on R&D through the Primary Industries Research and Development Act 1989 which makes provision for the funding and administration of R&D and marketing. Other legislative requirements such as those for animal welfare and intellectual property (PBRs and patents) also directly impact on R&D.

Individual industries also have their own R&D legislation or requirements, for example the sugar industry is bound by the Sugar Research and Development Services Act 2013.

Legislation can impact on the strategic policies of the National Primary Industries Research, Development and Extension Framework, commodity councils, and private and public funding and research bodies.

Contracts

Contracts are used for formal R&D agreements between individuals, organisations and funding sources. These contracts will stipulate the terms of funding and details regarding the research proposal, project details, intellectual property/ patents, commercial rights and royalties.

GRDC Research agreements provide good examples of R&D contracts or agreements between research bodies and funding sources.

LEARNING ACTIVITIES

Funding sources

Elizabeth Webster's The Conversation article Rural Australia has innovation lessons to teach us all (2014) provides a good overview of RDCs and R&D funding in Australian primary industries.

Article Questions:

1. Define the acronym RDC and outline the history of RDCs in Australia.
2. State how RDCs are funded.
3. For every A$1 invested in research in Australia, how much can be gained over 25 years according to the Treasury and Department of Finance?
4. Make a list of advantages from having an RDC in Primary Industries.
5. List the industries that benefit most from RDCs and explain why.

Summary Questions:

1. Outline the ways that funding can be obtained for research and development in industry.
2. Explain the limitations on securing funding for research and development in industry and the effect it can have on the development of new technology, produce and equipment.

Patents

Using the information above and the Patents section of the IP Australia, Australian Government website, answer the following questions.

Summary Questions:

1. Define a patent.
2. State the three types of patents available from the Australian Government.
3. Outline the benefits of obtaining a patent for the individual researcher/inventor.
4. Who can apply for a patent?
5. Explain the issues faced by inventors/researchers if they choose not to patent an idea/invention.

Plant breeders' rights

Using the information above and the Plant Breeder's Rights section of the IP Australia, Australian Government website, answer the following questions.

Summary Questions:

1. Explain the concept of Plant Breeders Rights (PBR).
2. List the rights gained by a breeder in registering a new variety of plant.
3. State the name of the current legislation regulating PBR and briefly describe the protection this legislation provides.
4. Discuss the potential issues for obtaining and not obtaining PBR?
5. Identify potential social and ethical issues for the ownership of intellectual property.

Legislation

Using the links below, answer the following questions:

Animal Research Act 1985 No 123

Plant Breeder's Rights Act 1994

Primary Industries Research and Development Act 1989

Sugar Research and Development Services Act 2013

Summary Questions:

1. List three pieces of legislation that impact on research and development in Australia.
2. For ONE of the above legislations, outline the main objectives of the act.
3. For the legislation chosen for question 2, discuss the advantages and disadvantages for researchers/inventors.

Use the scaffold on the following page to discuss issues related to the research and development of future primary industries technologies, produce or equipment in Australia.

Discuss issues related to the research and development of future primary industries technologies, produce or equipment in Australia.

Discuss: Identify issues and provide points for and/or against

ISSUE TO BE DISCUSSED	POINTS TO NOTE Statement of issue from your point of view (without using 'I') making your preferred side clear. Preview of each point.
Point for: Elaboration and support:	Topic sentence at the beginning of each paragraph followed by explanation and examples to illustrate point. Use linking words such as: therefore, because, however, for instance, for example.
Point for: Elaboration and support:	Brief summary of points for and against.
Point against: Elaboration and support:	
Conclusion	Draw conclusions regarding support for or against issue.

(Scaffold sourced from Oxford University Press website, 2016)

2. Developments in agricultural technologies

SYLLABUS POINT

Evaluate a range of new technological developments that may assist agricultural industries including: satellite technologies, computer technologies, biotechnologies, electronic identification systems and robotics.

Satellite technologies

Satellite technologies are changing the way we communicate, collect data, perform tasks and manage resources. Access to more accurate information about agricultural and environmental resources are changing our decision making processes and enabling us to farm in a more sustainable and productive manner.

A satellite to save Australia? We should have one of those. (2013). In this article Gordon Roesler, Australian Centre for Space Engineering, discusses the opportunities for agriculture to track soil moisture using satellite technologies.

Farming by Satellite. CSIRO Livestock Industries has developed technology that uses satellite images to measure the amount of feed on offer in pastures and how fast it grows.

Satellite data helps Australian ranchers meet the rising demand for meat in a changing world. (2016). NASA Landsat Science reports on the use of the Natural Resource Management Spatial Hub to help land managers make better decisions and manage climate challenges.

Global Positioning System (GPS) in agriculture. Brad Hussey and Tim Staier, BSES Limited*, answer the question 'What is GPS in agriculture?' with a comprehensive review into the technology and its application.

*BSES Limited is the principal provider of R, D&E to the Australian Sugar Industry.

Computer technologies

Math teachers used to call on the old line "you're not going to have a calculator with you all the time". Not only do we have that calculator, we've also got a computer, the internet and a world of knowledge in our pockets. As fast as computer technologies are changing so too are the ways we use them. Agriculture is not only keeping up with this changing world, it's pushing it along!

RamSelect.com.au is a web-based tool designed to help farmers achieve sheep breeding objectives by allowing them to harness the accuracy of Australian Sheep Breeding Values (ASBVs) on sale rams.

CSIRO Improving farming techniques by developing practical solutions for the agricultural community and industry. Computer technologies include remote monitoring of cattle condition, Yield Prophet and SoilMapp for iPad.

iFarm farm management software shows the capability of agricultural computer software programs which help with the day-to-day management and record keeping of agricultural enterprises.

Technology is changing the face of northern Australian cattle farming. (2014). Dave Swain, Central Queensland University and Meat & Livestock Australia, reports on the potential for EID and computer and software technologies to help automate livestock operations.

Telematics is changing farming for good. (2014). Jon Martindale reports on the way telematics are helping us access information in real time and the way this technology is changing farming.

ELSEVIER is an international journal of computers and electronics in agriculture.

Biotechnologies

At its simplest, biotechnology is technology based on biology by using living organisms, or their products, to create new ways to improve human, animal and environmental health. Biotechnology is an exciting industry with many amazing breakthroughs and just as much controversy behind it.

Plant breeding 1 YouTube playlist (NSW DoE) provides details on plant breeding biotechnologies and the importance of these technologies to agriculture in the future.

Australian Biotechnology Council of Australia (ABCA) is the national coordinating organisation for the Australian agricultural biotechnology sector. Their website hosts a range of information and a gene technology information pack is available on the materials page.

Australian Government Department of Agriculture and Water Resources. This website is a go-to for information on genetically modified (GM) trials, crops and regulation frameworks.

White Angus science put under the microscope. (2016). Shan Goodwin, Fairfax Agricultural Media, reports on gene editing technology being used to breed white Angus cattle with increased heat tolerance.

Male Chickens: Unnatural Selection, Landline. (2016). Caitlyn Gribbin reports on a breakthrough in gene marking technology which may enable the identification of gender prior to egg hatching.

Biotechnology and cotton. (2016). Cotton Australia provide a fact sheet specifically for students on biotechnology and cotton.

Electronic identification systems

Electronic Identification (EID) and Radio Frequency Identification (RFID) systems have revolutionised the way we identify and trace livestock and their movements. They help us to monitor and control biosecurity or food safety threats and have opened doors for farmers to monitor and record productivity details for individual animals and their herds.

NSW DPI provide information on NLIS – National Livestock Identification System.

Electro-com are suppliers of RFID technologies and their website provides information on these technologies and their potential to fully automate some farm processes.

Technology is changing the face of northern Australian cattle farming. (2014). Dave Swain, CQ University & MLA, reports on the potential for EID and computer and software technologies to help automate livestock operations.

Robotics

Robotic technology holds the key to increased agricultural production with fewer resources. It is also opening the door for a whole new range of agricultural careers, where labourers and tractor drivers are replaced by coders and computer technologists.

Dairy farming in the 21st Century YouTube playlist (NSW DoE and NSW DPI) give an extensive description of technological advancements in the dairy industry and specifically the FutureDairy Robotic Rotary dairy system. With links to information on EID, animal welfare and computer technologies these videos are useful to a range of Farming for the 21st Century outcomes.

UAVs in broadacre agriculture – is there profit in pixels? (2015). Ben Boughton, Nuffield scholar, provides an overview of unmanned aerial vehicles (UAVs) in agriculture and their potential uses.

Campbell's Comeback, Landline (2015). Pip Courtney speaks with Campbell Newman and Andrew Bate of SwarmFarm, a company developing agricultural robots.

Reducing labour and improving efficiency with Electronic Identification (EID) and automated drafting. (2015). Victorian Government Department of Agriculture has put together this informative guide to automated drafting systems.

The world's first robot-run farm will harvest 30,000 heads of lettuce daily (2016). Leanna Garfield, from Tech Insider, reports on the development of 'The Vegetable Factory' a vertical farming system whereby crops are grown indoors in controlled environments and labour is undertaken by robots, machines and technology.

Robotics to revolutionise farming and attract young people back to agriculture says Australian Centre for Field Robotics at Sydney University (2015). Sarina Locke, ABC Rural, learns about the variety of careers that agricultural robotics is creating.

LEARNING ACTIVITIES

Satellite technologies

Summary Questions:

1. List and outline a range of uses for satellite technology on farming practices in Australia.
2. Construct a table to identify advantages and disadvantages of satellites in farm management practices.
3. Explain how GPS is currently used in agriculture.
4. Predict possible future applications of GPS and satellite technology in agriculture.

Computer technologies

Summary Questions:

1. List and outline a range of uses for computer technology on farming practices in Australia.
2. Briefly describe the advantages of using computer technologies in farm management practices.
3. Compile a list of disadvantages to accessing and using computer technologies in farm management practices.
4. Predict possible future applications of computer technology in agriculture.

Biotechnologies

Summary Questions:

1. Define genetic engineering.
2. List some of the genetically modified food and fibre available in the marketplace today.
3. Outline the advantages of genetically engineering species for agricultural purposes.
4. Using one of the articles above, outline the methods used to manipulate the genes of the species to create a GM organism.
5. Discuss two concerns around the use of gene technology in agriculture.
6. Outline how gene technologies are regulated in Australia.

Electronic identification systems

Read the 'Technology is changing the face of northern Australian cattle farming' article and answer the following questions:

1. List the technologies being used by the northern Australian farmers in the article.
2. Describe how these technologies have changed the way these farmers work their enterprises.
3. Outline the advantages of these technologies for the northern Australian farmers using them.

Summary Questions:

1. Using the NLIS website link, explain the purpose of NLIS tags and tracking.
2. Briefly describe how EID and RFID systems work in livestock.
3. Identify the benefits of using EID and RFID technology.

Robotics

Watch the collection of YouTube clips Dairy farming in the 21st Century (NSW DoE and NSW DPI) and answer the following questions.

1. Describe the changes to dairy farming taking place with the introduction of robotics in the milking shed.
2. Predict the changes in careers that could take place if a large percentage of Australian dairy farms take up the use of this technology in the future.

Summary Questions:

Using the links provided, answer the following questions:

1. List and briefly explain some of the ways robotics are being used in industry across the world today.
2. Outline the advantages of using robotics in agriculture and provide examples to support your answer.
3. Outline some of the disadvantages of using robotics in agricultural production.
4. Predict the changes in careers that could take place if a large percentage of industries moved to robotics in the future for food and fibre production.
5. Design an idea for a robot in an industry you are interested in. Outline its use/function in the production or marketing process and describe the advantages of using this technology.

Use the scaffold on the following page to evaluate the impact on farm management practices of ONE recent technology that assists agricultural industries.

Evaluate the impact on farm management practices of ONE recent technology that assists agricultural industries.

Evaluate - make a judgement based on criteria; determine the value of.

ISSUE TO BE DISCUSSED	POINTS TO NOTE Statement of topic to be evaluated. Preview of points for and against your judgement (without using 'I').
Point for: Elaboration and support: Point for: Elaboration and support: Point against: Elaboration and support: Point against: Elaboration and support:	Topic sentence at the beginning of each paragraph followed by explanation and examples to illustrate point. Use linking words such as: therefore, because, however, for instance, for example, as a result. Points could also be advantages and disadvantages instead of for and against.
Criteria used to assess points for and against:	Criteria used to make a judgement could be used during the points for and against the argument to illustrate these more clearly.
Conclusion and judgement	Brief summary of points for and against. Restate judgement at the end either for OR against the argument.

(Scaffold sourced from Oxford University Press website, 2016)

3. Marketing of technology developments

SYLLABUS POINT

Evaluate methods that companies may use to market new technological developments.

Marketing

Marketing is the action or business of promoting and selling products or services, including market research and advertising. Marketing is much more than large advertising campaigns and attractive logos - it tells a story about your business or product and gives your customers a reason to purchase from you instead of the competition (business.gov.au Australian Government).

Agricultural marketing techniques are used in all aspects of agribusiness; from the small family farm to international companies and government agencies. Marketing is used to:

- achieve higher prices for produce, equipment or technologies
- protect from price fluctuations
- secure guarantees for the sale of their produce, equipment or technologies
- open up new markets or sales channels
- develop and maintain market share
- promote the use or consumption of produce, equipment or technologies.

A range of marketing methods are used to promote technologies. The product or technology, target consumers/ market, branding, price and marketing budget all influence the range of marketing methods employed in marketing campaigns.

Marketing case study: Topaz Rice

Topaz rice, a new long-grain fragrant rice, was developed by NSW DPI in partnership with Rural Industries Research & Development Corporation (RIRDC), SunRice and Rice Research Australia Pty Ltd to suit Australian temperate growing conditions. The marketing of Topaz rice began long before it became commercially available.

Topaz Rice was involved in **market testing** in Hong Kong where it was tested against competitive products for taste, appearance and flavour. This market testing provided the opportunity to identify strengths of the product, the specific market for the product and marketing methods to employ.

Following market testing, Topaz rice was **launched** at Parliament House in August 2014 under the SunRice **brand**, which consumers identify as a premium brand of rice. The launch was hosted by SunRice **brand ambassador** and well known chef and author Poh Ling Yeow.

Poh also represents the brand in SunRice commercials for Topaz rice and at **sponsorship** and networking events. Sponsorship of events such as the Taste Riverina festival provides the opportunity to tell the story of this new rice variety and increase brand recognition by consumers. The story of Topaz rice has also been told through other media channels such as the Landline story Fragrant Success, which outlined its development and benefit to Australian agriculture.

Marketing methods such as those identified have helped raise the identity and consumer awareness of Topaz rice as a quality rice product developed in Australia for Australian conditions as well as for local and international consumers.

Marketing case study: John Deere Precision Agriculture

John Deere is one of the most recognisable **brands** in the world. Their **merchandise** is found throughout the world and their marketing strategies are at the forefront of marketing design. **John Deere** may have been the original users of **content marketing** to help drive traffic, conversions and/or leads. Content marketing started for the company back in 1895 when they developed and released The Furrow, an educational magazine resource for their customers and farmers. The Furrow is still published today, albeit now in a digital version. Kate Gardiner explores John Deere's content marketing history and strategies in her article The Story Behind 'The Furrow'.

The John Deere **'story',** and their corresponding branding, speaks to our deepest hopes and dreams and creates impressive brand loyalty. Kay Plantes discusses the company's marketing strategies in her article John Deere – Branding and business models at their best.

As technologies have led to the precision agriculture phenomenon, John Deere has developed their Agricultural Management Solutions suite of technologies. These technologies are marketed in dealerships, on their website, via commercials and a range of videos, through brand ambassador Zach Johnson as well as featuring in The Furrow.

Strategic marketing methods have created impressive brand awareness and customer loyalty for John Deere. Marketing of new technologies uses their proven recipes with a few new ingredients, such as **online campaigns**, which make use of the digital technologies.

LEARNING ACTIVITIES

Marketing

Summary Questions:

1. For each of the words in bold, write a definition that relates to its use in the article.
2. After reading the two marketing case studies and exploring the links available, choose another agricultural product or company that you feel is well marketed. Include a picture of one of its marketing campaigns or strategies. Looking at all aspects of the marketing for the product/company, evaluate the overall effect of the methods used.
3. Use the scaffold on the following page to evaluate the marketing methods which have been used to market ONE recent technology.

Evaluate the marketing methods which have been used to market ONE recent technology.

Evaluate - make a judgement based on criteria; determine the value of.

ISSUE TO BE DISCUSSED	POINTS TO NOTE Statement of topic to be evaluated. Preview of points for and against your judgement (without using 'I').
Point for: Elaboration and support: Point for: Elaboration and support: Point against: Elaboration and support: Point against: Elaboration and support:	Topic sentence at the beginning of each paragraph followed by explanation and examples to illustrate point. Use linking words such as: therefore, because, however, for instance, for example, as a result. Points could also be advantages and disadvantages instead of for and against.
Criteria used to assess points for and against:	Criteria used to make a judgement could be used during the points for and against the argument to illustrate these more clearly.
Conclusion and judgement	Brief summary of points for and against. Restate judgement at the end either for OR against the argument.

(Scaffold sourced from Oxford University Press website, 2016)

Managing processes in agricultural systems

1. Reasons for adopting technologies

SYLLABUS POINT **Explain the reasons for adopting technologies in agriculture.**

Labour

Many technologies support agricultural production by making it possible to produce more, using less labour. While technologies are changing labour dynamics on the farm they are also supporting the development of a new and exciting range of careers in agriculture.

On the other hand, increased labour training to effectively use technologies may impede their uptake. In developing countries where the cost of labour remains low it may not be economically viable to implement expensive technologies.

Access to information

Technologies are providing access to immense amounts of data and information on crop, livestock, soil, water, machinery and environmental conditions.

People may choose to adopt technologies because data collection can assist primary producers, agriculture professionals and researchers, to understand their production performance and limitations, and make decisions to enhance productivity and sustainability that best utilise the resources available to them.

However the excessive data and information that may be gathered can overwhelm users and obstruct their uptake of the technology.

Animal identification

Electronic identification (EID) and radio frequency identification (RFID) technologies make it possible to clearly identify individual animals. Improved animal identification technology combined with ICT gives users the ability to monitor individual animal production and automate some production operations.

While EID/RFID tags are a requirement of the National Livestock Identification System (NLIS) the costs of establishing and maintaining EID/RFID systems on farm can impact on the uptake of these technologies. Additionally the physical layout of a property or yards can impact on the practicality and use of these technologies on-farm.

Use of inputs such as water and chemicals

Technologies can significantly influence on-farm inputs. Some technologies, such as precision and automated weed control, which detects and sprays only weeds, can reduce chemical inputs dramatically. Similarly, new strains of cotton can be grown with less water thereby decreasing the water inputs required. Reduced inputs can reduce expenditure and make production more sustainable and profitable.

Although many technologies reduce inputs some may increase other inputs, for example the FutureDairy Robotic Rotary dairy system can increase electricity inputs as it is required to run 24 hours per day which can be a significant drawback of the technology.

Record keeping

Farmers have historically had a notebook in their pocket in which to record important information as it comes to hand. The issue with this was the loss of information when that notebook fell in the dam or was lost in the paddock. The technological revolution has changed the way farmers record information and maintain their records. A number of apps and software programs are now available which allow producers to record and share information quickly and easily with the backup potential of cloud storage and access from multiple devices.

Computer literacy is required for the uptake of many record keeping technologies and this may impact on their adoption. Another obstruction to adoption of record keeping technologies can be the software, hardware and internet requirements to use them.

LEARNING ACTIVITIES

Use the scaffold on the following page to explain the reasons for adopting ONE recent technology.

Explain the reasons for adopting ONE technology

Explain – Relate cause and effect; make the relationships between things evident; provide why and/or how

ISSUE TO BE DISCUSSED	POINTS TO NOTE Statement of topic to be evaluated. Preview of points for and against your judgement (without using 'I').
Point for: Elaboration and support: Point for: Elaboration and support: Point against: Elaboration and support: Point against: Elaboration and support:	Topic sentence at the beginning of each paragraph followed by explanation and examples to illustrate point. Use linking words such as: therefore, because, however, for instance, for example, as a result. Points could also be advantages and disadvantages instead of for and against.
Criteria used to assess points for and against:	Criteria used to make a judgement could be used during the points for and against the argument to illustrate these more clearly.

(Scaffold sourced from Oxford University Press website, 2016)

2. Adopting a technological development

SYLLABUS POINT

For ONE recent technological development:

1. explain the reasons for the development of the technology
2. outline the historical development of the technology
3. describe in detail the technological development
4. evaluate the impacts of the technological development in terms of: economic, environmental, social, legal and managerial factors

A large number of technologies have been identified throughout this resource. Select one of those technologies, or one of your choice, for your students to learn about. Examples of technologies to study include:

1. Radio-frequency identification and/or electronic identification systems
2. Satellite technologies
3. Computer technologies
4. Robotics
5. Biotechnologies

Reinforce your students learning by providing a practical experience with agricultural technology, by organising a class visit from someone who uses the technology or provide time for students to conduct independent research into a technology of their choice.

LEARNING ACTIVITIES

Summary Questions:

1. Outline the reasons for the introduction of your technology.
2. Describe the operation of your technology.
3. Construct a table that summarises the advantages and disadvantages of your technology.
4. Evaluate the impact of your technology. In your answer consider economic, environmental, social, legal and managerial factors.
5. Outline three other technologies that might be incorporated into a farming operation that uses your technology.

The following sample answers have been provided as a guide only. Individual answers will vary and reflect your choice of technology and learning.

Adopting robotic milking systems – sample answers:

1. Outline reasons for the introduction of robotic milking systems in Australia.

The principal reason for the introduction of robotic milking systems has been the high cost of labour in Australia. The use of computer-controlled robotic milking machines allows higher milk output per unit of labour to be achieved than is possible with conventional hand operated milking systems. This brought about by the ability of robotic milking systems to milk cows more than twice each day, hence maximising their milk production each day.

2. Describe the operation of a robotic milking system.

All cows in the herd are fitted with computer readers that allow them to be individually identified. They move voluntarily onto a stationary robotic milking station or enter a rotating milking platform with a number of robotic stations. Computer controlled robotic arms wash the teats, attach the milking cups, remove them individually when milk flow ceases and then apply iodine to the teats before the cow leaves the platform. During milking the milk is analysed. Cows showing any symptoms of infection are directed into a holding pen so that they can be given attention by the operator at a later time. Those whose milk shows no abnormalities are directed back to fresh pasture after receiving an allocation of supplementary feed according to their stage of lactation and milk output. Cows are free to enter the milking facility several times each day.

Farm managers are notified of any malfunctions in the robotic milking system via messages sent from the computers controlling the system to a smartphone.

3. Construct a table that summarises the advantages and disadvantages of robotic milking systems when compared to conventional ones such as a herringbone system.

Advantages	Disadvantages
• They allow higher yield per cow to be achieved via more frequent milking • They give farmers more time to concentrate on other aspects of cattle management such as pasture production and herd health • They reduce the need for dairy farmers to begin work very early each day • Farmers can receive immediate feedback about the performance of individual cows • Data collection from individual cows is much easier	They are very expensive to construct and install

4. Evaluate the impact of robotic milking systems. In your answer consider, economic, environmental, social, legal and managerial factors.

Managerial factors:

- Allows farmers to spend more time attending to other aspects of farm management such as pasture production, pest and disease control, financial management, reproductive management and environmental management
- Large amounts of data are relatively easy to collect in a robotic milking system

Economic factors:

- May (but not necessarily) improve profit margins by increasing output per cow and per unit of labour
- Reduce reliance on labour (which may be difficult to source)
- May allow an increase in the scale of the farming operation

Social factors:

- Reduces the need for very early starts and late finishes to the working day
- May give farmers more family and leisure time ie. Lifestyle changes possible

Environmental factors:

- No direct environmental impacts but some potential for small environmental gains due to improved management of the farm as a whole

Legal factors:

- Robotic milking systems must be designed so that they can meet legal requirements associated with animal welfare, workplace health and safety and human health

5. Outline three computer-related technologies that might be incorporated into a farming operation that uses robotic milking.

Electronic identification

A range of devices that incorporate electronic numbering systems (such as collars and ear tags) are available to dairy farmers to identify individual cows in their herds. A computer transponder reads the numbers and identifies the cow as she passes by it. These devices are essential for the operation of a robotic milking system. For example, they are required to determine if the cow is ready to be milked again, to direct cows through appropriate "smart gates" and for the on-farm monitoring of their milk output and quality. Health and reproductive data can also be attached to these computer records.

Electronic identification allows farmers to collate data about their animals and to use this to make well informed decisions about the management of individual cows and the herd as a whole.

Electronic pasture monitoring

Devices which measure pasture height can be attached directly to a quad bike, or towed behind one. When driven over a pasture they take a series of measurements of the pasture height. These are then converted into an estimate of pasture availability expressed in units of kilogram per hectare of dry matter.

The use of these devices allows farmers to more accurately determine stocking rates so as to help maximise the efficiency of pasture usage. Pasture growth rates can also be estimated, thus assisting in the planning of grazing management.

Computerised feed allocation

Computerised feed allocation systems allow concentrate feeds to be delivered to cows on an individual basis, either while in the milking bail in conventional dairy systems or while in the designated feeding area in robotic milking systems. A computer reader identifies the cow via her electronic identification device and the feeding device delivers a set amount of food to that cow by placing it in a trough in front of her. The amount delivered is set by the farm manager based on the cow's genetics, age, stage of lactation and body condition.

Feeding cows concentrates individually like this, allows farmers to utilise the feed more efficiently than with "flat-rate" feeding. It may also lead to increased total milk output from the herd, improved reproductive performance and reduced herd health problems.

Research methodology and presentation of research

1. Research into technological developments

SYLLABUS POINT

Analyse a research study of the development and/or implementation of ONE recent agricultural technology in terms of:

- design of the study
- methodology of the study
- collection of data for the study
- presentation of data
- analysis of the data
- conclusions and recommendations.

Selecting and analysing a research study

There are a number of research studies available on technological developments; however it is important you select a **published** research study focused on a **recent** agricultural technology. As a general rule of thumb, if the technology is established and/or commonly used in production it is probably too old to study. To enhance learning and engagement select a research study related to your local context or students interests.

Analysis of a research study includes identifying the components of the study and relationships between components. Focus questions, such as the following may help with analysis of a research study:

- Who is the author and what are their qualifications?
- What is the problem they are solving or the goal of the research?
- What is their approach/methodology to solving the problem?
- What are the benefits and limitations to their approach/methodology?
- How did the author collect and analyse their results?
- What conclusions did they make from their results?
- What application/useful benefit do the researchers/you see for this work?

Amanda Graham suggests techniques to help understand and analyse research studies in her article A Guide to Reading and Analysing Academic Articles.

Sample research studies

Rumination and activity levels as predictors of calving for dairy cows.

This research study aims to determine the rumination profiles and activity levels of pasture-based dairy cows around calving and use this information to predict the day of calving. The authors monitored 27 cows under experimental conditions to assess the correlation of rumination profiles and activity levels to calving.

Preliminary results with a vacuum assisted harvest system for apples.

This study involved trialling a vacuum tube transport system and automated bin filler to assess fruit bruising at various stages in the harvest system.

Conceptual control design for harvester robot.

This paper describes the development of the "robot eye" system for a cocoa harvester robot that can recognise the target fruit in real plantation environments and can predict the actual distance of the target object.

LEARNING ACTIVITIES

Analysing a research article template

Abstract

The abstract is a summary of the entire article. It contains all the key points that you need to know to understand the work performed. You should still have questions after reading the abstract, but it should be enough information to help you understand the article as a whole. In your article…

What was studied? .....

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What agency conducted this research? .....

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How was this research conducted? (Basic outline) .....

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What was determined by this research? (Final conclusions of the researchers) .....

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The Introduction

An introduction usually begins with background information which is obtained by credible sources outside of the research conducted in the experiment. It aims to give a basis for the experiment being conducted.

What are key pieces of information provided by the researchers in their introduction.....

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Following the background information the article will address the aim of the experiment (the question the researchers are trying to answer), the hypothesis (predicted outcome) and a rationale (evidence they have researched to support their hypothesis).

What is the Research Question addressed by this research .....

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What is the Hypothesis? .....

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What is their Rationale? .....

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Methods

This section provides detailed information about how the experiment was conducted.

Briefly summarise how the researchers conducted the experiment:.....

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Results

The results section lists the raw data collected and trends analysed, usually in graphs. This section may refer to data collected as being 'significant'. 'Significant' means the data collected was statistically different to the controls within the experiment, "no significant difference' means data was statistically the same as the controls or not a big enough difference to have an impact on the outcome.

Summarise their results here. What key pieces of information did the researchers collect? List them all:

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Discussion (or Conclusion)

This is the most important section of the research article. It will state whether or not the hypothesis was supported by the data. It will conclude with the implications of the researcher's work, if it will have an effect on the industry and describe where research would need to continue to advance or improve this technology.

Did the data collected support the author's hypothesis? Explain: .....

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What impact do the authors think their work will have on their respective field? In other words, how do they think their work will affect the advancement of their field?

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What do the authors believe will be the next step in this work? .....

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Do you agree with their analysis of their work? Explain:.....

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2. The need for research

Explain the need for research in the development of agricultural technologies.

Research and development for agricultural growth

Research and development into agricultural technologies is important to current and future generations and can:

- support environmentally sustainable management practices and natural resource management.
- enhance productivity and the economic viability and sustainability of agricultural production and commodities.
- ensure food security for an ever-increasing population.
- address changing consumer demands and preferences.
- improve animal husbandry practices and animal welfare standards.
- decrease reliance on external inputs such as water and chemicals.
- increase the reliability of climate and weather predictions.
- help producers prepare for and adapt to climate variability.
- protect our industry, environment and society from the impacts of pests and diseases.
- address social disadvantage in rural areas.

For more information on R&D check out the NSW DPI Agriculture research webpage and The Crawford Funds article 'Why international agricultural research matters'