Maintaining pollination for plant production using Artificial Intelligence.

STUDENT WORKSHEETS

YEAR 7-10

This resource has been developed by:

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STORM & FLOOD INDUSTRY RECOVERY PROGRAM

Contents

NB: Double click on underlined text throughout the document to go directly to the website link and/or worksheet page.

PIEFA'S Storm and Flood Industry Recovery Program (SFIRP) is funded by the Australian and NSW Government under the Disaster Recovery Funding Arrangements through the Department of Regional NSW – Sector Recovery and Resilience Grants.

SURVEYS
TEACHERS, CAREERS ADVISORS AND STUDENTS

We hope you find this resource valuable, relevant and enjoyable. We would be grateful for your feedback on things that you liked and worked well, and areas that you feel could be improved upon. We invite you to please complete the below survey/s after using the resource. Your responses will be used to continuously improve PIEFA's food and fibre education resources.

ACCESS THE **TEACHER** AND **CAREERS ADVISOR** SURVEY HERE OR USE THIS QR CODE.

ACCESS THE **STUDENT** SURVEY HERE OR USE THIS QR CODE.

Lesson objective

The following sequence of learning will adopt the 5E model of pedagogy. Students will research pollinators and their place in nature and begin to make connections about the importance of pollinators to the food and fibre industry. Students will explore their schoolyard to collect data to determine its biodiversity, whilst making connections to past and present practices of sustainability evolving through Dreamtime stories.

Students will have the opportunity to present their thinking about biodiversity, sustainability and pollination and develop their vocabulary and scientific conceptual thinking. Students will confirm the connections of these elements to the food and fibre industry and explore the benefits of applying technology and artificial intelligence to the plethora of challenges it faces.

Students will apply coding and algorithms to classify and detect beehive pests, such as small hive beetle (*Aethenia tumida*) amongst European honey bees. The activity will have students learning about artificial intelligence by developing their own AI models. An extension activity is offered to have students build an automated Integrated Pest Management (IPM) physical control system to deter pests. This activity will focus on the small hive beetle as this is an easy to find and handle pest, but this activity may be extended to other pests with some innovative design (e.g. waxmoth, varroa, etc.).

Students will conclude that technology serves as a plausible solution to real world problems, including declining pollination. Students will see the developed solution using artificial intelligence as a base scenario to optimise into the future and understand the potential of such technologies is still in its infancy. As a final output, students will create a 1-2 minute video of all the activities, available to the teacher as a summative assessment.

Lesson sequence, timing, resources and equipment

6 x 1-hour lessons

Lesson sequence	Time guideline	Worksheet	Resources and equipment
VIDEO CREATION	All lessons	Worksheet 1 Video Creation Worksheet 2 Video Checklist	iPad / laptop / desktop Internet connection
ACTIVITY 1 Engage	1 x 60 minute lesson	Worksheet 3 Mundiba and the Honey, a Yarning circle	iPad / laptop / desktop Internet connection
ACTIVITY 2 Explore	1 x 60 minute lesson	Worksheet 4 Pollination, germination and plant growth, a recap Worksheet 5 Flying insect biodiversity survey, schematic school grounds and data analysis	iPad / laptop / desktop Internet connection
ACTIVITY 3 Explain	40 minute lesson (lead lesson into Activity 4)	Worksheet 6 Pollinators, biodiversity, sustainability and the food and fibre industry Worksheet 7 Using AI to maintain pollination for plant production	iPad / laptop / desktop Internet connection
ACTIVITY 4 Elaborate	2 x 60 minute lesson	Worksheet 8 Desktop AgTech	iPad / laptop / desktop Internet connection
ACTIVITY 5 Evaluate	1 x 60 minute lesson	Worksheet 1 Video Creation Worksheet 2 Video Checklist	iPad / laptop / desktop Internet connection

WORKSHEET 1

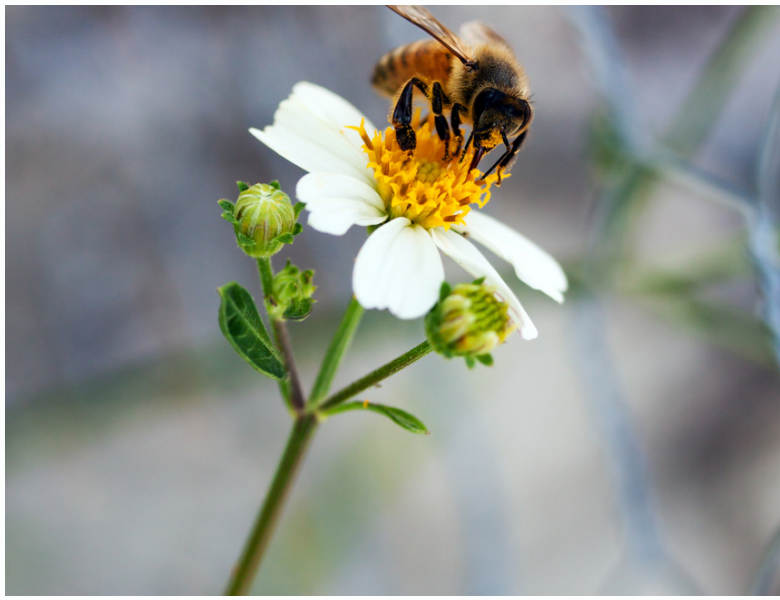
Video Creation: Maintaining pollination for plant production using Artificial Intelligence

Video instruction

You will be learning about pollination, biodiversity, sustainability and the role these factors play in the food and fibre industry. To capture your journey towards understanding these connections and the application of Artificial Intelligence (AI) in maintaining pollination for plant production and its linkage to the food and fibre industry, you will be expected to create a short 1-2 minute video. This is your chance to be creative and innovative with how you convey to your class what you have learnt, and how that will help in building a future that is sustainable and resilient against the myriad of issues our world faces - be it food shortages, biodiversity degradation, waste, climate change, etc.

Follow the checklist on the next page to ensure you have gathered enough images, recordings, and observations (evidence to demonstrate your understanding) for your video. Use the following suggestions as a guideline to help create your art (Yes, art! The food and fibre industry needs a variety of skilled workers, such as: scientists, engineers, marketing officers, artists, AI computer programmers, and actors to ensure its success!).

The key message from your video must emphasise the importance of biodiversity, pollination and sustainability to Australia's food and fibre industry and how AI can benefit this landscape.



WORKSHEET 2 | Page 1 of 2

Video Checklist: Maintaining pollination for plant production using AI

Access an online video editing tool (e.g. Capcut, iMovie). Throughout the lessons, use the following checklist to capture evidence of your developing understanding of maintaining pollination for plant production using AI and its importance to Australia's food and fibre industry. At the close of each lesson, tick off that you have gathered the data. Remember, this is only a guideline; evoke your creative genius to make the best video you can!

ACTIVITY 1: ENGAGE	
☐	Take an image of the whole class yarning circle.
☐	Record your group members talking about their interpretation of the Dreamtime story of Mundiba and the Honey - what do they think it means?
☐	Take an image or record your group members discussing Mundiba's behaviours and whether your group have witnessed similar behaviour in today's society.
☐	Record your group's understanding of biodiversity and why it is important to the food and fibre industry - try incorporating the words pollinators, sustainability and productivity in your response.
ACTIVITY 2: EXPLORE	
☐	Take an image of your group members exploring the school yard to investigate flora and fauna habitats.
☐	Take images of any flora and fauna your group finds in the school yard.
☐	Record your group's observations and understanding of pollination, biodiversity and sustainability (use your own words and don't worry if it is not completely correct!).
☐	Did you find evidence of flora and fauna habitat? Take images and record whether or not you think your schools environment is thriving or struggling with biodiversity.
☐	Record your groups understanding of biodiversity and why it is important for the food and fibre industry - try incorporating the words pollinators, sustainability, productivity in your response.
☐	Capture your data analysing through image or recordings.

WORKSHEET 2 | Page 2 of 2

Video Checklist: Maintaining pollination for plant production using AI

ACTIVITY 3: EXPLAIN	
☐	Take an image of your group investigating / researching protecting pollinator biodiversity and record some fun bee facts.
☐	Record your groups understanding of pollination, biodiversity, sustainability and why it's of vital importance to the food and fibre industry.
☐	Describe some of the challenges to address pollinator decline and hypothesise the impact this could have on the food and fibre industry. Start to brainstorm some solutions or ideas about how you can help maintain pollination for plant production using artificial intelligence (don't worry if you don't know yet!). Brainstorm as many ideas as possible - even if they seem unrealistic, there is no right or wrong answer when it comes to technology application!
ACTIVITY 4: ELABORATE	
☐	Take an image of your group collecting data sets as input into the AI model.
☐	Record your group's opinions on the benefits of AI to the food and fibre industry.
☐	Take an image / screenshot of your AI model output.
☐	Describe how the AI algorithm can be improved with more datasets, and synthesise how this can help fight pollinator decline in the ecosystem.
ACTIVITY 5: EVALUATE	
☐	Create your video using an online video editing tool such as Capcut or iMovie.
☐	Get creative with your video, ensuring it is about 1-2 minutes in length.

WORKSHEET 3 | Page 1 of 2

Mundiba and the Honey, a Yarning circle

A long time ago there was a great drought and food became very scarce. All were hungry and worried for the water of the river was very low and few fish could be caught. If hunting and food gathering had been successful, the meal was shared and enjoyed by all.

Mundiba was a young hunter who spent most of his time looking for wild bees. He went out every morning soon after sunrise and did not return until sunset and each time he was empty-handed but he greedily ate his share of the food collected by the others. He kept saying that the honey was as scarce as the food they collected however the gubi [Clever Man] of the tribe had his suspicions of Mundiba and instructed his spirit servant to follow Mundiba next morning on one of his hunting expeditions.

The small invisible spirit followed Mundiba the very next day and saw him find a nest and making a hole in the trunk with his tomahawk, remove the nest and eat with relish a considerable amount of this rare sweetness of the bush. The invisible spirit of the gubi followed Mundiba from tree to tree and saw him eating greedily each time. This act of greed outraged the spirit servant and so he began to sing to the tree to persuade the tree to make the hole smaller and smaller and soon Mundiba's arm was stuck in the tree. That is where Mundiba remained and he was found dead hanging by his arm from the tree.

The suffering and death of Mundiba was an example for later generations. His greediness, selfishness and refusal to obey the laws deserved severe punishment. Those who behaved in a similar manner could expect strict discipline which might come in unexpected ways thus you were warned!

WORKSHEET 3 | Page 2 of 2
Yarning questions

Can we continue as a society treating the environment like Mundiba did?

Do you think it is acceptable for community members to take more food and fibre than others? Why / Why not?

What are some of the challenges facing bees / environment / flora / fauna?

Why is it important to protect bees / environment / flora / fauna?

What action can be taken to ensure a prosperous future for our society?

Vocabulary link from yarning circle and observations.

1. Pollination
2. Biodiversity
3. Sustainability

INQUIRY QUESTION

What is the connection between the above terms and the food and fibre industry?

WORKSHEET 4

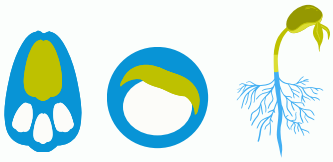
Pollination, germination and plant growth - a recap

The diagrams and explanations below serve as a reminder about the role of pollinators in plant production. Begin to explore what might happen to the food and fibre industry if pollinators were to become extinct.

Pollination and fertilisation

Pollination is an essential process that allows SOME plants to reproduce and produce new seeds. The fascinating partnership between plants and their pollinators helps create a beautiful, diverse and PRODUCTIVE world.

Pollination in plants is the act of transferring pollen grains from the male anther of a flower to the female stigma of a different flower. This leads to fertilisation and is essential for plant production. Some examples of pollinators includes bees, butterflies and birds.



Fertilisation occurs after pollination. Fertilisation occurs when a male sex cell fuses with a female sex cell. Once this is complete, the seed will undergo a dispersal process to become a new plant.

Plant's Growth Stages

Stage 1

The first stage is when a seed begins to **germinate**. It absorbs water and nutrients from the soil, and the embryo inside the seed starts growing.

Stage 2

The seed develops into a young plant called a seedling. It grows roots that anchor it in the soil and shoots that reach towards the sunlight.

Stage 3

The plant develops more leaves, stems, and sometimes branches.

Stage 5

The plant produces flowers, which are the reproductive structures of the plant. The flowers attract pollinators to transfer pollen.

Stage 6

The flowers develop into fruits. The fruits protect the seeds and help in seed dispersal to new locations.

VIDEO LOG REMINDER: Record your thoughts about what might happen to the food and fibre industry if pollinators become extinct.

WORKSHEET 5 | Page 1 of 3

Flying insect biodiversity survey, school schematic and data analysis

Watch the video **PIEFA SFIRP Pollinators and biodiversity for food production***(5:06) and complete the activity below.

1. Explore your school's grounds to investigate biodiversity. Look for clues about bee habitat, and write down your quantitative observations in the table below.

Habitat	Insect biodiversity	Plants in flower biodiversity
Example answers / explanations	How many species of insect can you see? For example, there may be many different species of bees. When observing the habitat, use the following measurement technique: For 30 seconds, in your field of vision, how many different insects do you see? Do this 3 times and take the average.	The number of different plants in flower phase for pollination.
1. School vegetable plots		
2. School orchard		
3. Cropping areas		
4. Production species		
5. Native Australian gardens		
6. Ornamental/exotic gardens		

*Website link - https://www.youtube.com/watch?v=Rk8POx9Izt8

WORKSHEET 5 | Page 2 of 3

Flying insect biodiversity survey, school schematic and data analysis

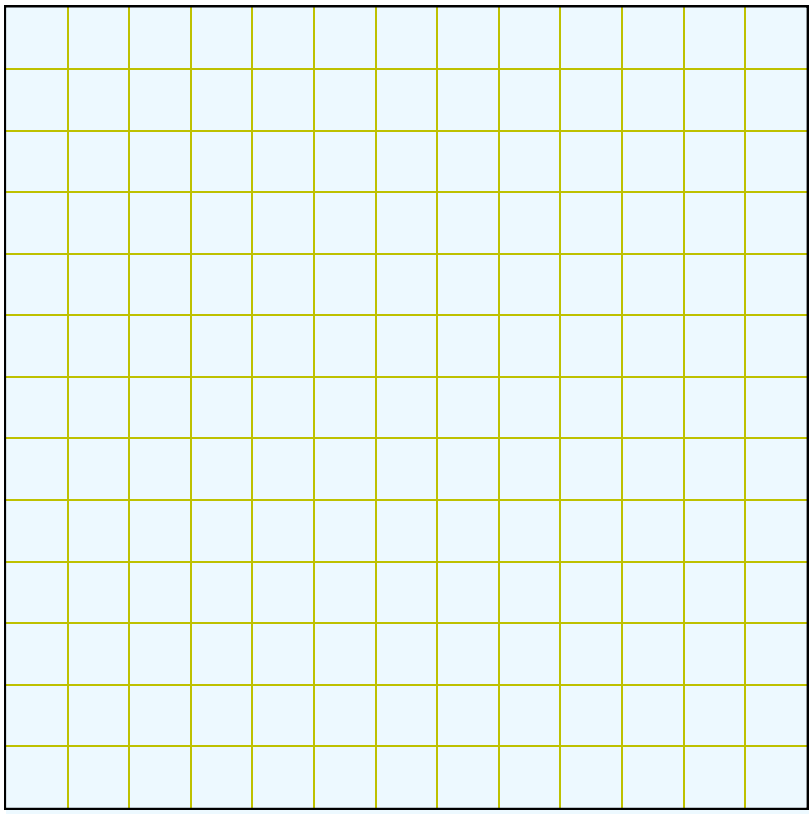
2 Draw a schematic of your school grounds to illustrate the locations / orientation of the different habitats with reference to your classroom. Don't forget to include a 'north' compass rose.

WORKSHEET 5 | Page 3 of 3

Flying insect biodiversity survey, school schematic and data analysis

3. Use the information in your data table to make a simple column graph to indicate your school's biodiversity then answer the questions. Use the dataset values 'Insect Biodiversity' and 'Habitat' to populate your graph. If you find it difficult to gather enough data for 'Insect biodiversity', use the field 'Plants in flower biodiversity'. Remember to label both axes.

School Biodiversity Survey



Habitat

4. Review the data in your 'School Biodiversity Survey' and make a general statement of your school's biodiversity. Watch the video **What is Biodiversity?*** (6:14) to help inform your response.

*Website link - https://www.youtube.com/watch?v=y18o0mACCQs

WORKSHEET 6

Pollinators, biodiversity, sustainability and the food and fibre industry

Watch the video **Sustainable pollination project protecting pollinator biodiversity*** (4:10) and answer the following questions.

1. Identify what the Agricultural Research Officers are trying to achieve with their project.

2. What data acquisition technique did the Agricultural Research Officers use to understand what type of pollinators were visiting the farm? List three examples of these pollinators.

3. What do pollinators (just like humans) need to survive?

4. Describe the benefits to pollinators of the 'floral enhancers'.

5. Explain why pollinators are important to our society. Refer to the food and fibre industry in your response.

*Website link - https://www.youtube.com/watch?v=y18o0mACCQs

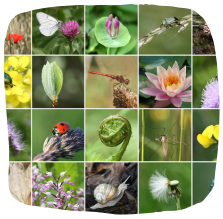
WORKSHEET 7

Using AI to maintain pollination for plant production

Pre-requisite background information to AI application.

It's important that you have a robust understanding of the following terms. This will give you the **WHY** (reasoning) for the application of **AGRICULTURAL TECHNOLOGY** (in this case, artificial intelligence) in the next activity. You have the freedom (and responsibility) with your group to **choose** how you **learn** these terms - whether it be a drama play, Dreamtime storytelling, writing and rote learning or reviewing and testing yourselves - you are in control of how you learn this!

Making connections



Biodiversity

Biodiversity is the variety of all life forms on Earth - the different plants, animals, fungi, protozoans, algae, micro-organisms (and more) and the ecosystems of which they are a part.

Pollinators

Pollination is one of the most important mechanisms in the maintenance and promotion of biodiversity and life on Earth. Pollinators and pollination are critical for food production and human livelihoods, and directly link natural ecosystems with agricultural production systems.

Challenges to biodiversity

Presently, the abundance, diversity and health of pollinators and the process of pollination are threatened by direct drivers, including: habitat fragmentation and land use change, pesticides, parasites and diseases, invasive alien species and climate change.

Application of AI

The current decline of pollinators and pollination has increased awareness of the value and appropriate management of this important ecosystem service. The tech giants are on board, with a number of artificial intelligence tools being developed as we speak.

VIDEO LOG REMINDER: Record how your group learn the pre-requisite background information and terms.

WORKSHEET 8 | Page 1 of 9

Desktop AgTech

During the next activity, your project team will develop AI to deter pest attacks on a bee hive - a key strategic response to the challenges associated with pollinator decline. Follow the steps to build your own AgTech solution!

STEP 1 PREPARE THE TRAINING DATASET

Firstly, you need to identify and collect a dataset to train the AI algorithm to differentiate and classify European honey bees and small hive beetles.

a) Explore Anatomy

Let's analyse both of these insects and discuss how they visually differ - these features are what the AI model will use to determine the difference between these insects. Observe the two images and fill in the blanks, highlighting the similarities and differences of each creature.

Similarities	Differences

WORKSHEET 8 | Page 2 of 9

Desktop AgTech

b) Collect and filter the data

In your project team, conduct an investigation to collect as many pieces of data (finding images online or taking photos of your samples) of the European honey bees and the small hive beetle. The goal is to collect as many samples as possible.

The following is recommended when collecting online images:

- Try Google Image searching with different search terms that each insect is known by (e.g. their scientific name, their common name, etc.) and 'photo' (
- Help reduce bias in our model (discussed in detail later) by collecting images that have similar background imagery - i.e. aim to collect images with a light / white background.
- Aim to collect a minimum of 20 images of each insect.
- Aim to collect images that are 'square' where possible, as the model crops images to square when they are used.

The images in your dataset should look similar (but not exactly the same) to those shown below. Use screenshots of the small hive beetles and European honey bees shown if you cannot find images online or within your school ground.

Small hive beetle

WORKSHEET 8 | Page 3 of 9

Desktop AgTech

European honey bee

You can access and add these images to your own dataset by downloading them here: https://www.integratedstem.com.au/beehive-sentry/

Now you have the dataset for each insect, you will soon provide the images in the 'training' dataset to your model to learn from, and you will test how well it works with your 'testing' dataset. To split the dataset images into 'training' and 'testing' datasets, follow the steps below:

- You will be providing the images in the 'training' dataset to your model to learn from (more information about this is on the next page). A typical train:test dataset split is approximately 80:20.

- Split your entire collection of images into 2 folders: a training and a testing dataset folder (e.g. if you have 40 images of European honey bees in your image database, split this by putting 32 images into the 'training' folder with the remaining 8 into the 'testing' folder).

- Access example training and testing dataset folders (NB: This is provided as an example, though it is highly recommended you have more images than are in these example datasets) from https://www.integratedstem.com.au/beehive-sentry/

NB: If the google folders are not available or cannot be accessed please contact PIEFA or IntegratedSTEM: office@piefa.edu.au

WORKSHEET 8 | Page 4 of 9

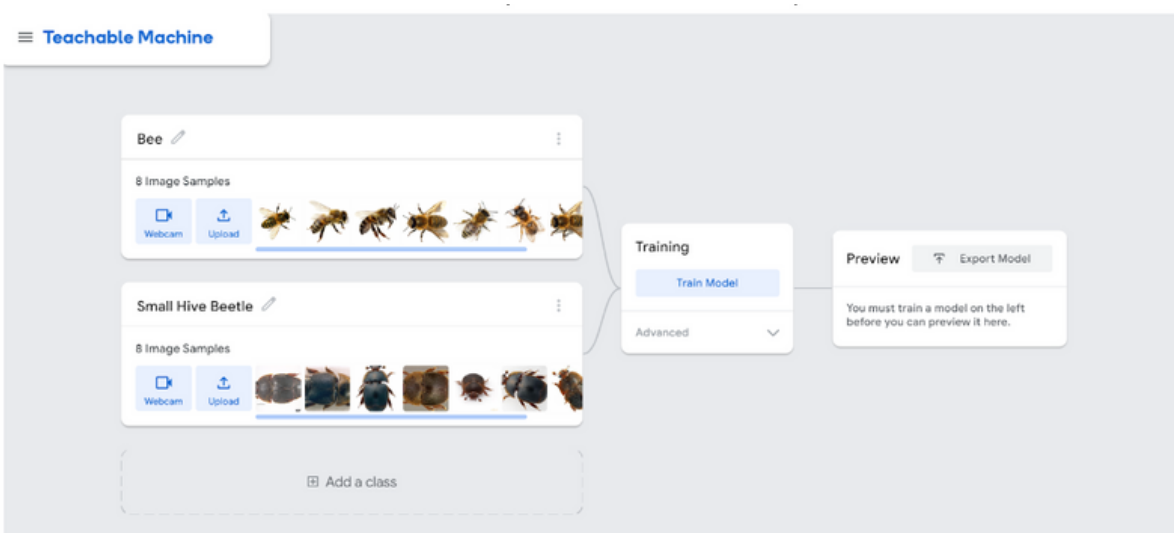
Desktop AgTech

STEP 2 TRAIN YOUR AI MODEL

Now, let's create our AI model by using Teachable Machine online program to train the AI classification model using the following steps:

1. Open Teachable Machine (https://teachablemachine.withgoogle.com/) and click 'Get Started'.
2. Select: Image Project > Standard image model.
3. Label 'Class 1' as 'Bee' and 'Class 2' as 'Small Hive Beetle'.
4. In the upper box (now labelled 'Bee') upload your training dataset of bee images by clicking 'Upload' and drag-and-drop your images into the top blue box. Repeat this step to upload the training dataset of small hive beetle images in the lower box (now labelled 'Small Hive Beetle').

NB: **Your screen should look like this (see below screenshot).**



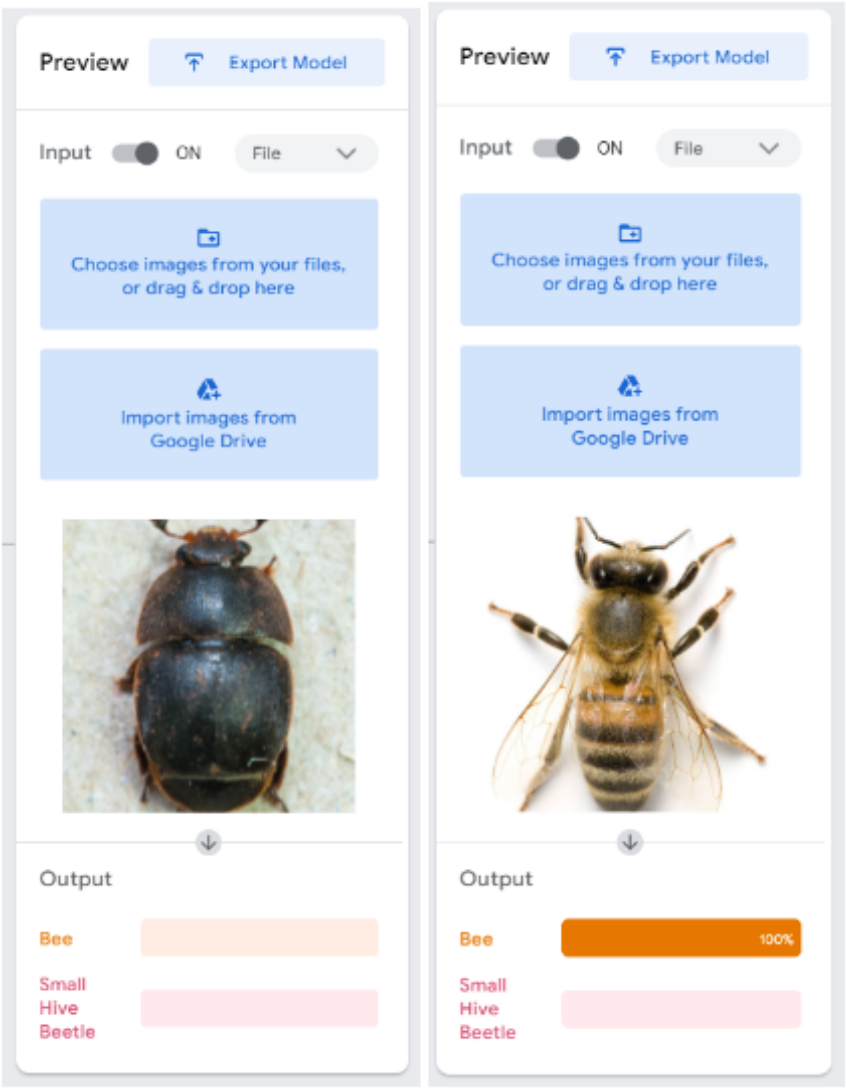
5. Click 'Train Model' and wait (this may take between 20 - 60 seconds, depending on the number of images uploaded). When the model is trained it will open a window on the right hand side of the screen, which will open your webcam to show a live view of the model's estimation of what it thinks it is seeing in the webcam. It you are able to show the webcam your 'testing' images (either by printing them or having access to them on a phone screen) use this method, otherwise proceed to the next your
6. Select 'File' from the dropdown menu (default label: 'Webcam'), and then drag-and-drop any photo from your test datasets (bee or small hive beetle) into the right hand side box labelled 'Choose images from your files, or drag and drop here'.

WORKSHEET 8 | Page 5 of 9

Desktop AgTech

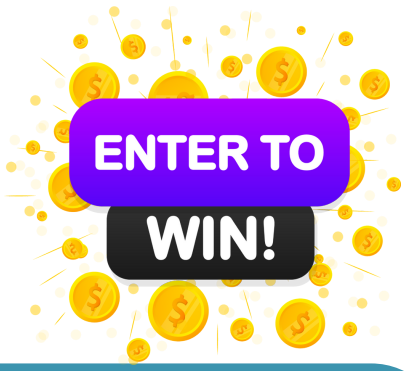
STEP 2 TRAIN YOUR AI MODEL

If your algorithm correctly identifies the images as a ‘bee‘ or ‘small hive beetle‘ consistently, your model is working! Example shown below.



Sometimes, the model may be unsure (less than 100%) or even wrong (thinks a small hive beetle is a bee) - that is normal. Though it is the goal, AI models are only predictions and are rarely ever correct 100% of the time. A model that is 70% correct is generally considered a high performing model in the realm of AI.

Try out the model and see if yours identifies bees and small hive beetles correctly more often than this one: https://teachablemachine.withgoogle.com/models/PwB7MHmw1/



Submit a photo or schematic of your optimised solution to info@integratedstem.com.au for your chance to **win** a water-based STEM kit and recognition in social media for your school.

WORKSHEET 8 | Page 6 of 9

Desktop AgTech

STEP 3 SHARE YOUR AI MODEL

Now you have built your model, you can share it with others to use and evaluate. This process will help to eliminate biases and enhance your model's performance.

1. Click 'Export Model' and then 'Upload my Model'. This should now display 'Uploading...' on the screen. For a model with 40 images, this may take around 3 - 5 minutes, though with more images this may take considerably longer.
2. After the link appears, click 'Copy' on the right hand side of the textbox and save this link where you'd like to keep it. To share your model, simply send this link to someone to open in their own browser.

STEP 4 EVALUATE YOUR AI MODEL

Share your models with each other by using these links, and choose 2 of these models to evaluate as a class using the following steps:

1. Define a test dataset (e.g. perhaps select 3 images of a 'bee' and a 'small hive beetle') to evaluate the models on.
2. Give these images, one at a time, to each of the models you are evaluating. Record the classification certainty (this is the percentage given by the model) for each image, and repeat for both models. If a model incorrectly classifies an image (e.g. it thought an image of a bee was a small hive beetle), give the image a score of 0%.
3. Take an average of the certainty for each model for its performance over the entire testing dataset and determine whether the models' performance differs or is the same.
4. You can then evaluate the models based on how representative their training dataset is from the test dataset that was selected. For example, if one model performed worse than the other, you can deduce that the images used to train this dataset were less similar to the test dataset than that of the higher performing dataset (e.g. perhaps you chose to only use images with white background in the test dataset and the model that performed worst had more images with non-white background, etc.). The reality is that no one knows the answer as to why a model performed better or worse, but we can only make inferences based on the data that we provided to train the model.

WORKSHEET 8 | Page 7 of 9

Desktop AgTech

REMEMBER DATA IN = DATA OUT

The interesting (though sometimes frustrating) thing about AI is that even the people that create the models don't know how it works and, therefore, won't understand exactly why it doesn't work well when it underperforms. The general rule of thumb is that an AI model is only as good as the data it is given to learn from. Typically, higher performing models are those with larger datasets that are high quality.

- A larger dataset simply means that more photos are used to train the model. The more photos of bees and small hive beetles that are provided, the better the model can identify features between these insects.
- A high-quality dataset is harder to define but typically refers to the relevance and diversity of images that are provided in the dataset. This helps remove biases that the AI may have incorrectly identified as key differentiating factors based on the images provided. For example, if only photos taken side-on of a bee are used to train an AI model, then a photo of a bee from above may confuse the algorithm because it had never been told this was an image that is 'still a bee' just taken from a different perspective.

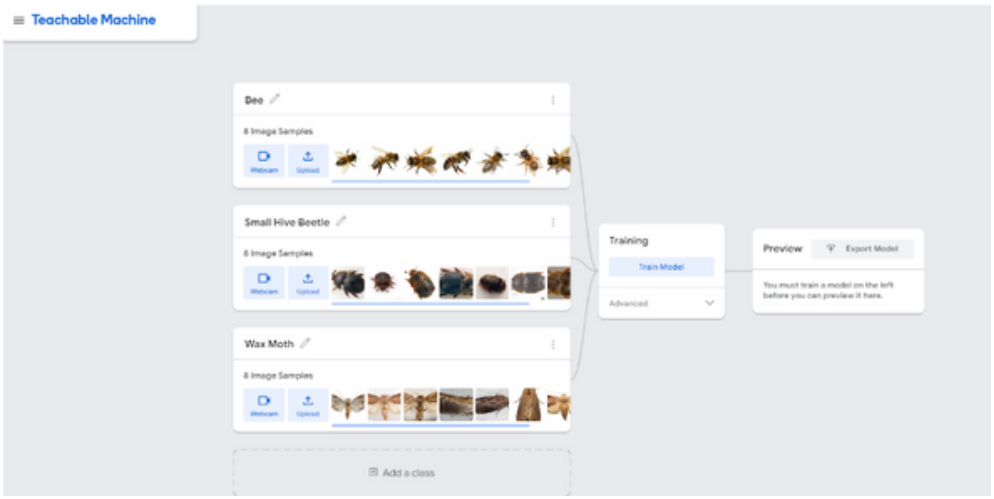
WORKSHEET 8 | Page 8 of 9

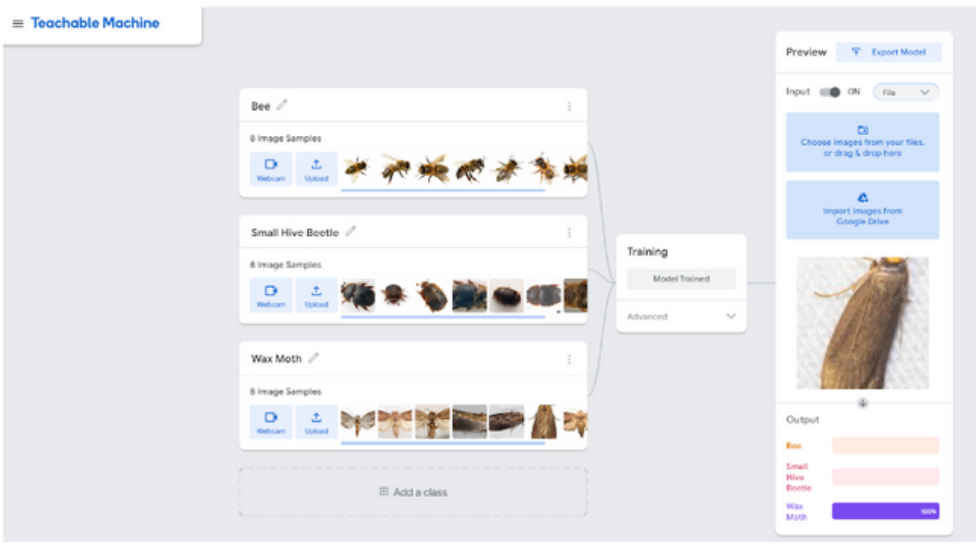
Desktop AgTech

STEP 5 ENHANCE YOUR MODEL

These AI models can classify more than 2 images - so expand your model to be even more powerful by adding more classes to classify. For example, repeat Steps 1 - 3 to classify images of the following insects: European honey bees, small hive beetle and wax moth.

Try out this example model and see if yours identifies bees, small hive beetles and wax moths correctly more often!
https://teachablemachine.withgoogle.com/models/ip_F9tU-G/





WORKSHEET 8 | Page 9 of 9

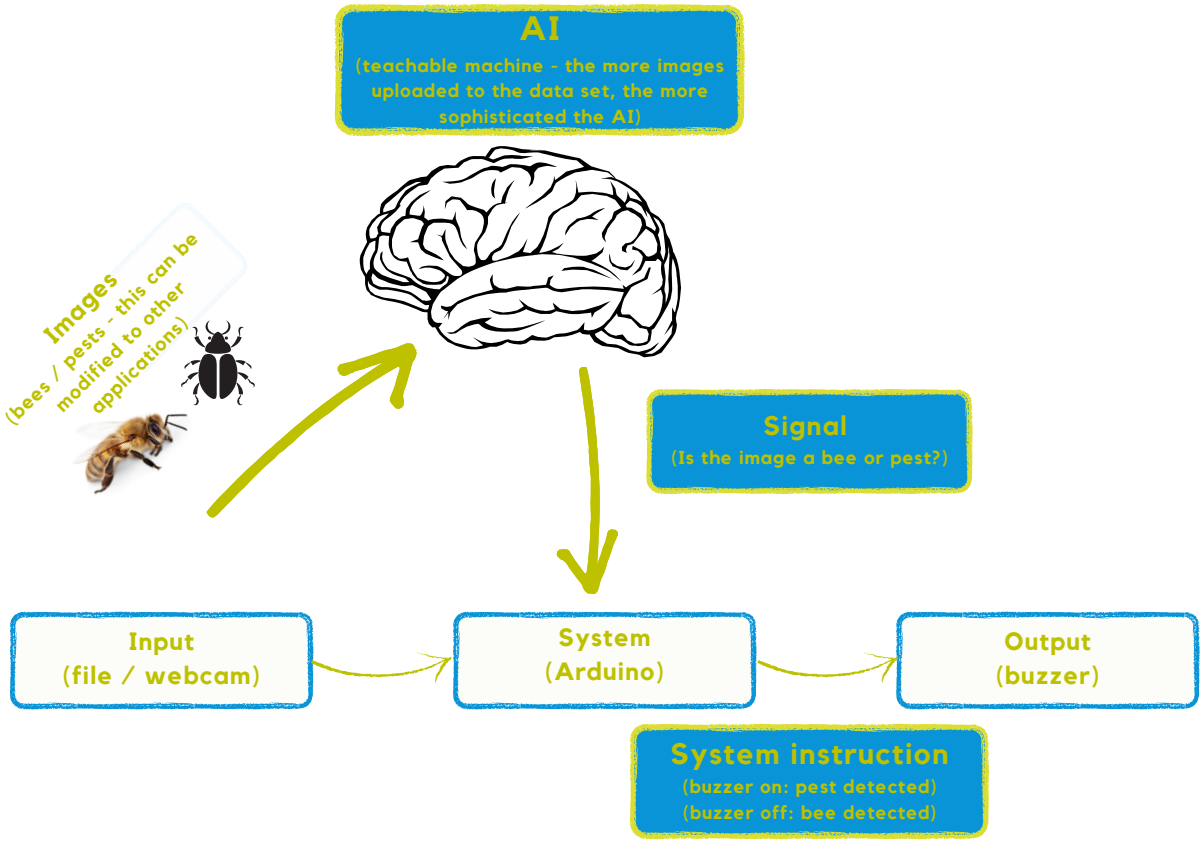
Desktop AgTech

SUMMARY Artificial intelligence and its application to the food and fibre industry

The AI model developed in this activity (a built teachable machine that can differentiate between 2 or more distinct images/data sets) has a number of food and fibre industry applications. All you need to do is change the 'input' data (i.e. the images) with the AI capability remaining the same. See examples below of input data that could be uploaded to this AI model:

- fruit picking: 'ripe fruit' and 'rotten fruit'
- crop health: 'healthy leaf' and 'unhealthy/wilting leaf'

1. Can you think of another issue / problem farmers face that this AI model could help with?



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