DISCOVERY AWARD

CREST AWARDS

Machines of the future

Teacher pack

TEAM PROJECT

Working in teams, students are challenged to design a household product that uses machine learning.

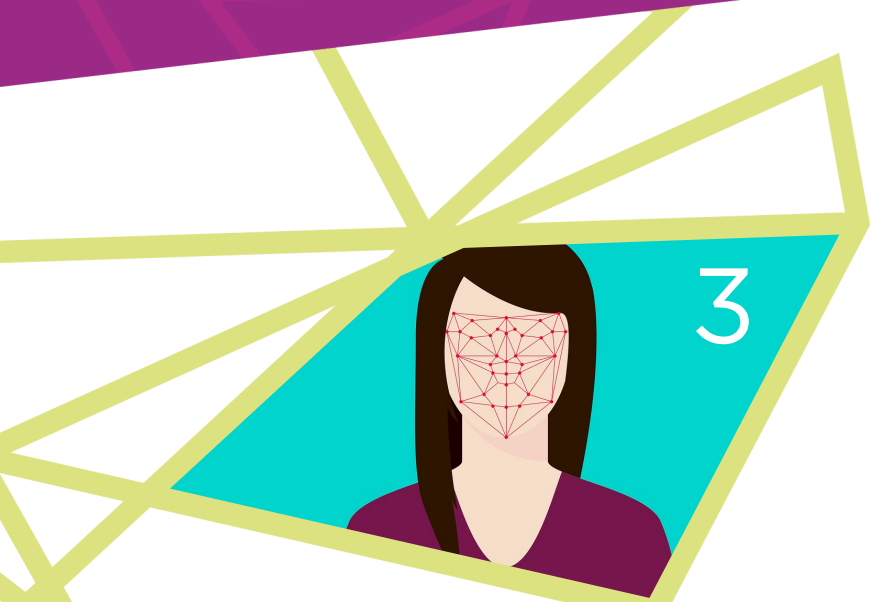
#Machinelearning
#Artificialintelligence
#Yourhome

IN PARTNERSHIP WITH

BRITISH SCIENCE ASSOCIATION

THE ROYAL SOCIETY

Contents



Background

Over the last few years we have seen big developments in the field of machine learning – a topic that is no longer just a thing of the future. Many of us now interact with systems using machine learning on a daily basis, such as image and voice recognition on social media and virtual personal assistants.

Artificial intelligence and machine learning

What is AI? AI is an umbrella term that refers to a suite of technologies in which computer systems are programmed to exhibit complex behaviour, when acting in conditions of uncertainty.

What is machine learning? Machine learning is a technology that allows computers to learn directly from examples and experience in the form of data. Traditional approaches to programming rely on hardcoded rules, which set out how to solve a problem, step-by-step. In contrast, machine learning systems are set a task, and given a large amount of data to use as examples of how this task can be achieved or from which to detect patterns. The system then learns how best to achieve the desired output.

What is an algorithm? An algorithm is a list of rules which can be followed to solve a problem or make a decision. Check out this really simple explanation from BBC Bitesize https://www.bbc.com/bitesize/articles/z3whpv4

What do we mean by machine? In the context of machine learning a 'machine' usually refers to a computer that learns directly from examples and experience in the form of data.

What is a robot? In the context of machine learning and AI, a 'robot' typically refers to the embodied form of AI; robots are physical agents that act in the real world. These physical manifestations might have sensory inputs and abilities powered by machine learning.

The future of machine learning

In the future, it is likely we will continue to see advances in the capabilities of machine learning, and this exciting process has the potential to change the way we use data in a range of areas.

Tools are already being developed to support healthcare, policing, telecommunications, driving and farming.

What will be next? The social and economic opportunities which will follow the increased use of machine learning are significant.

The Royal Society

The Royal Society is the world's oldest independent scientific academy in continuous existence, dedicated to promoting excellence in science. The Society works to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

The Royal Society's machine learning policy project is investigating the potential of machine learning over the next 5-10 years and exploring how this technology can be developed in a way that benefits everyone. The Royal Society has launched a report setting out the action needed to maintain the UK's role in advancing this technology while ensuring careful stewardship of its development.

The Royal Society has supported the development of this CREST Discovery resource.

Overview

Machines of the future has been specifically developed to meet the CREST Discovery Award requirements. By undertaking the activity and completing the reflective CREST Discovery Passports, all your students should be able to achieve an Award, which you can enter them for at the end.

This resource can be delivered in school during lessons, as an extracurricular activity or as an enterprise activity. The project can be completed over 5 lessons or as a one day event.

To deliver these activities no prior knowledge of machine learning is needed.

The challenge

In this 5 hour project, students aged 10-14 will work in teams to find out about machine learning and come up with an idea for using it in a home environment.

Students will:

- Research existing machine learning tools and explore the future potential of this technique.
- Develop a concept for their own machine learning tool.
- Decide on what data they would need to collect and how they would source the data.
- Create a plan for how the machine might process the data and how this would be useful for humans.
- Draw a detailed design for the physical form of their machine learning tool.
- Develop ideas about how to market their product.

Learning objectives

- Reflect on how they and their families have experienced technological change and consider future technological changes they might experience.
- Explore what machine learning tools there are and how they work.
- Understand the potential of utilising machine learning tools and the capacity of machine learning, specifically in reference to SMART appliances.
- Use their knowledge of AI and machine learning to design a product in a real-world context.

Materials and printing list

Activity	Materials/printing for a group of 30	PowerPoint slides
Introduction and starter	❑ 1x Teacher facilitation questions (1 per adult) ❑ 1x Everyday examples of machine learning (1 per adult) ❑ 30x Discovery Passports (1 per student) ❑ Internet access and sound for PowerPoint display	1-11
Workshops (divide class into 3 groups and rotate between workshops, reusing most materials)	**Workshop 1 (materials reused)** ❑ 5x Workshop 1 instructions (1 per pair) ❑ 5x Workshop 1 decision chart (1 per pair printed on A3) ❑ 5x Workshop 1 decision card sets (1 per pair) **Workshop 2: (materials reused)** ❑ 5x Workshop 2 instructions (1 per pair) ❑ 5x Case study 1: Netflix cards (1 set per pair) ❑ 5x Case study 2 and 3 cards (1 set per pair) ❑ 5x Flow diagram OR Basic flowchart (1 per pair) ❑ 5x laptops with internet access (1 per pair) ❑ 10x headphones and splitters (1 per student) **Workshop 3: (worksheets used once)** ❑ 15x Workshop 3 instructions/worksheet (1 per pair) ❑ 5x laptops with internet access (1 per pair)	12-16
Design	❑ 10x Team roles (1 per group) ❑ 10x Idea development (1 per group) ❑ 10x Planning guide (1 per group) ❑ 10x Idea sheets (1 per group printed on A3)	17-19
Research and Planning	❑ Poster making materials (paper, coloured pens)	19
Presentations and plenary	❑ Created posters	20-21

Timings (for a one-day project)

Activity	Description	Timing
Starter	PowerPoint presentation to introduce the topic of machine learning, the design challenge and purpose of the project. Welcome and introduction to CREST Awards.	40m
Workshops	A rotation of three 20-minute interactive workshops to engage the students and develop their knowledge and understanding of machine learning. Activities for the workshops are designed so they can be student led with light facilitation. They can be adapted from workflows for younger students.	1h 10min
Break		
Research and Planning	Students work in their teams to research ideas and start to develop their own concept for a machine learning tool.	1h 10min
Lunch		
Design	This section focuses on a more detailed design of the machine learning tool. The teams will work together to develop their concept, draw a scale model, and start to think about marketing considerations for their product.	1h 20m
Presentations	Team's finalise and deliver their 5-minute presentations. Teachers and students provide constructive feedback, and have a chance to ask questions.	30m
Plenary	Students reflect on their learning and complete their CREST Discovery passport.	10m

Top tips

- To inspire your students, why not invite a STEM ambassador or Inspiring the Future volunteer to introduce the project or give feedback on students' presentations.
- When considering timings, start with the end of your school day and work backwards.
- Account for timings that cannot be changed, such as lunch breaks, and schedule around them.
- Try and plan the day to give your students as much time as possible for the practical activities.
- Before presentations, allow 5 minutes for students to clear their tables and tidy away any equipment.
- You may wish to adapt these timings, depending on the age and ability of your students.

Timings (for a five-lesson project)

Activity	Description	Timing
Starter and one workshop	PowerPoint presentation to introduce the topic of machine learning, the design challenge and purpose of the project. Welcome and introduction to CREST Awards. Students try one of the three 20-minute interactive workshops and develop their knowledge and understanding of machine learning. Activities for the workshops are designed so they can be student led with light facilitation. They can be adapted from workflows for younger students.	1h
Two workshops	Recap previous session. Facilitate the remaining two 20-minute interactive workshops to engage the students and develop their knowledge and understanding of machine learning. Activities for the workshops are designed to be student led, with hands-off teacher supervision.	1h
Research and Planning	Students work in their teams to research ideas and start to develop their own concept for a machine learning tool.	1h
Design	This section focuses on a more detailed design of the machine learning tool. The teams will work together to develop their concept, draw a scale model, and start to think about marketing considerations for their product.	1h
Presentations and plenary	Team's finalise and deliver their 5-minute presentations. Teachers and students provide constructive feedback, and have a chance to ask questions. Students reflect on their learning and complete their CREST Discovery passport.	1h

Top tips

- To inspire your students, why not invite a STEM ambassador or Inspiring the Future volunteer to introduce the project or give feedback on students' presentations.
- Students might like to do extra work on their designs between lessons.

Step-by-step guide

Pre-project preparation

1. Read through the background information in the pack, and explore this infographic from the Royal Society to familiarise yourself with the topic.
2. It's worth having a quick play around with:

- Quick Draw,
- Teachable Machine,
- Teachable Machine (demo version),
- Shadow Art,
- Imaginary Soundscape and
- Giorgio Cam.

These are tools that students will explore in Workshop 3. You might want to ask them to just look at two or three of these.

3. Download the PowerPoint and print out copies of the CREST Discovery Passport and workshop handouts. Follow the printing instructions on page 5 and adapt for your groupings.
4. Divide the class up into groups of 3-6 students. There are six different roles that can be doubled up for smaller groups.

Starter (20min)

1. Use the PowerPoint and instructions on page 10 to introduce machine learning.
2. Introduce CREST Discovery Awards and handout CREST Discovery Passports to the students.

Video (10min)

Watch the video on slide 7 of the PowerPoint. Use the following prompt questions to recap and check the students' understanding. Check answers in slide notes:

- What did you learn that you didn't already know?
- How does the machine know what to do?
- How does the machine know which images are bees and which are threes?
- How does the machine improve?

This video is referenced in the Workshop 2 student handouts.

Quiz (10min)

Use the quiz on slide 9. Read out each question and take ideas from the class about whether or not the product in question uses machine learning. See if the class can figure out which tools exists, which ones use machine learning, and which ones are completely fictional.

Take a show of hands to decide whether to select 'yes' or 'no' and then reveal and read out the answer.

Workshops

These three interactive workshops will develop students' understanding of machine learning. Activities for the workshops are designed to be student led, with hands-off teacher supervision. Split the class into three groups and set up a rotation for the three 30 minute workshops.

Give out the workshop handouts and materials. Put up timings on the board.

Workshop 1 – Would you trust a machine?: students will sort different potential machine learning jobs based on their usefulness and how much they would trust a machine to do the job. If possible, print the sheet in A3 to give students more room.

Workshop 2 – Machine learning now: students will look at video case studies, investigating how machine learning works in a real-world context, how different data sources are used in AI systems, and illustrating how these tools use machine learning. All students should complete the Netflix activity. You then have the option of handing out the basic flowchart (simpler) or the flow diagram (more complex) for your students to use with case studies 2 and 3 depending on their age and ability.

Step-by-step guide

Workshop 3 - Teach a machine: in their groups, students experiment with machine learning using a range of different AI powered tools. Students will explore how machine learning uses examples, rather than instructions, to make decisions, and how the more examples (or data) we train the machine with and the more varied these examples, the better it will be.

1. Whilst students are completing the activities, drop in on the sessions and use prompt questions to guide any groups that are struggling.
2. After the students have completed all three workshops, bring the class back together again and discuss each in turn. Reveal the answers for workshop 2 on the PowerPoint.

Research and Planning

Students work in their teams to research ideas and start to develop their own concept for a machine learning tool.

1. Split students into groups of 3–6. Give each group a Planning handout (found on page 9 of the Student Pack), a team roles sheet, a copy of the Idea Development handout (found on page 10 of the Student Pack) and an A3 copy of the idea sheet (separate). You may want to allow them time to research online in which case each group will need an internet connected device.
2. Divide up the roles between students in each group using the descriptions on the PowerPoint: Project Manager, Software Lead, Research Lead, Risk Lead, Design Lead, Marketing Lead. If the groups are smaller they can double up the roles.
3. Support the groups to identify problems, generate ideas and carry out relevant research if they have online access.
4. Encourage students to consider their idea and ask, 'Is it machine learning?'

Design

This section focuses on a more detailed design of the machine learning tool. The teams will work together to develop their concept, draw a scale model, and start to think about marketing considerations for their product.

1. Go over the design outputs slide on the PowerPoint and bring up the prompt questions to guide the students in their designs and presentations.
2. Hand out poster making materials to the teams.
3. Encourage the teams to draw some draft ideas before creating their design.
4. Ask questions to help students develop their ideas further. Prompt them to identify the different machine learning elements in their design: data, algorithm, output, feedback, improvement.
5. Once students have completed their design, they will need to put together all their work into a 5 minute presentation format. Encourage them to think about who will do the explaining during the different elements of their presentation. Encourage each student to present and discuss what their role in the project was.

Presentations

Allow the students time to finalise their 5 minute presentations.

Ask each group to deliver their presentation. Allow time for yourself and the rest of the class to provide constructive feedback and have a chance to ask questions.

Plenary

Time for students to reflect on their learning and complete their CREST Discovery passport.

Starter activity

Starter Activity

Objective
Understand what machine learning is and identify examples of machine learning in everyday life.

Preparation
Slide 6 of the PowerPoint shows two images designed to trigger students to think of examples of machine learning in their own lives. More examples are given on page 11 of this pack. The most relevant examples are likely to be different depending on the age and cohort of students. You may want to substitute your own images into the slide or print some out.

Timing
20 minutes

1. Introduction
Use slides 1-4 to introduce the day and the challenge.
Show slide 5 - What is machine learning? Discuss in pairs and then feedback ideas as a whole class.

Summarise by explaining that:

"Machine learning is a technology that allows computers to learn directly from examples and experience in the form of data.

"Machine learning systems are set a task and given a large amount of data to use as examples of how this task can be achieved or from which to detect patterns. The system then learns how best to achieve the desired output."

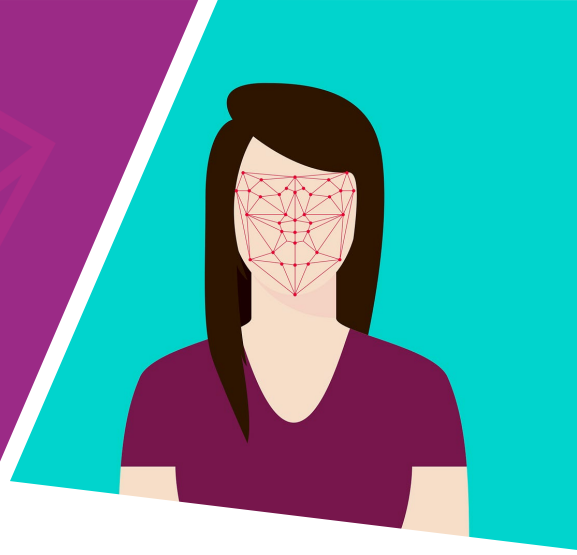
2. In pairs or small groups
Ask students to share examples, from their own lives, that they think might use machine learning. They might also have family members who have experiences of using machine learning. Use the table on page 11 of this pack as well as the images on slide 6 in the PowerPoint to help prompt if they are short of ideas.

3. Discuss
Ask students to share some of their ideas, stories and experiences with the class and discuss if and how machine learning is being used. Use the questions on page 12 of this pack to help. You might have to look up some of the answers later as it's not always obvious if something uses machine learning or not. Ask students to consider how effective it was. Did it work well? Are there examples of things going wrong?

4. Identify
Use the examples shared to draw out different ways machine learning is used in everyday life. You could use the images on slide 6 of the PowerPoint to highlight examples that students may have encountered. For each one ask the students how they think machine learning is utilised. Use the table on page 11 of this pack for reference.

5. Summarise
Over the last few years we have seen big developments in the field of machine learning. Machine learning is no longer a thing of the future, many of us now interact with systems using machine learning on a daily basis, such as image and voice recognition on social media and virtual personal assistants.

Everyday life examples of machine learning



Example of machine learning in everyday life	Where might students have come across it?	How is machine learning used?
Facial recognition	Apple tablet and phone security	Facial recognition is trained using machine learning by processing and classifying thousands upon thousands of images.
Chatbots	Google, Hey, Alexa or Siri chatbots, interacting with customer service chatbots on websites.	Some just use non-machine learning AI to mimic human conversation, but some use machine learning to mimic human conversation that either keeps the human chatting longest or achieves the most customer satisfaction based on feedback data. Have you ever used a chat function on a website? Do you think it was a human or a chatbot? Were you asked to rate your satisfaction after the interaction?
Translate apps	Website translators. Reading comments in another language on social media. Communicating with others who speak a different language. Learning a new language.	A lot of translate apps do not use machine learning, they use a lot of pre-programmed rules instead. But some newer tools are starting to use machine learning to build statistics-based translation systems. By looking at millions of examples of already translated material, machine learning can be used to predict how things will be translated through data rather than by following set rules.
Online recommendations	YouTube or Netflix. Shopping online.	Some sites, such as Amazon, use machine learning to provide recommendations and encourage users to buy more products. They start by recommending random things and over time the machine learning tool refines the recommendations by analysing the data about what was bought and what was not.
Fraud detection	Students may have come across it if they have an email account with a SPAM filter. They may have family members who have experienced credit card fraud that was spotted by machine learning technology.	Rather than programming fraud detection software to look for particular words or phrases, more modern fraud detection software uses machine learning, giving the tool lots of examples of emails or transactions and asking it to categorise it as fraudulent or not. The tool gradually gets better at identifying which emails or transactions are fraudulent or not, although we don't really know what they are looking for!
Self driving vehicles	Students may have heard about this in the media.	Self driving cars use machine learning, rather than being programmed to follow the rules of driving. Instead, the software is fed millions of files of videos and images of driving that is good and driving that is bad. Gradually, this improves the way the car drives itself and how it reacts to situations.

Facilitation questions

Use these questions to facilitate discussion around examples of machine learning in everyday life. Use the questions throughout the other activities to remind students what machine learning is. These questions can also be used to help students refine their ideas during the research, planning and design stages.

Examples of machine learning

- Can you think of any other examples in your life which you think use machine learning?
- What is it for and who uses it?
- Can you describe how it works?
- What information does the machine or system use to make decisions?
- Can the machine improve by itself without being told what to do? Can it 'learn'?
- Is it reliable, does it always get it right?

Is it machine learning?

- Is this an example of machine learning?
- How do you know it is machine learning?
- What is the **input** or data used by the machine?
- What is the **algorithm -** what is the purpose of the machine?
- What is the **output -** what does the machine do?
- What is the **test -** how does the machine know how well it is working? Is there a chance to rate its performance?
- What is the **feedback -** how does the machine improve its performance and learn from mistakes?

Coming up with ideas

- How will this make your life easier?
- Could both those ideas be combined?
- Is it machine learning?
- What might your idea look like?
- Can you draw it?
- How will you explain your idea clearly and simply?

Considering the risks

- Do you think people will want to use this machine or system?
- Why/why not?
- What concerns might people have?
- What if the data (images etc) was shared publicly?
- What could go wrong?
- Who would be responsible (pay for any damage) if that happened?
- How could you overcome these problems?

CREST Discovery Award

Students should complete the CREST Discovery Passport, available at www.crestawards.org/sign-in. When you assess the passport to submit the Awards, you will be recognising the skills that students will gain through participation in the day.

Preparation

Ready to get going with CREST? Sign up for a CREST account here: www.crestawards.org/sign-in

Create a new Discovery Award project with the names of the students and the title of the project.

Run the project

We've created some super handy packs to help you deliver a successful Discovery Day. The activities in these packs can be done in one day or over a period of shorter sessions, whichever suits you. Students should spend 5 hours on the project.

You can download the Discovery Passport when you create your CREST account by following the link above.

Make sure you complete a risk assessment before running the project:

- Unless stated, no external links have been checked by CLEAPSS.
- Safety checked but not trialled by CLEAPSS.

Reflection

So, your students have been hard at work and completed their CREST project, but don't let this be the end of their learning. At the end of the project ask all students to complete their Discovery Passport. This is a chance for them to reflect on all the interesting things they've learnt and the invaluable skills they have used.

Enter your project for a CREST Discovery Award

Hard work deserves a reward! Celebrate and certify your students' achievements by entering their project for a CREST Discovery Award. Simply

1. Log in to your CREST account at www.crestawards.org/sign-in
2. Select the project and upload a sample of the students' Passports or other project evidence.
3. Check the participating students have met each of the criteria on the teacher assessment page.
4. Finally, complete the delivery and payment details to order your snazzy certificates.
5. Congratulations on completing CREST Discovery!

What next?

The scientific discovery doesn't need to end here. Students can have a go at the next level up - CREST Bronze.

Don't keep all the fun to yourselves, encourage others to take part in CREST projects and share the wonder of science. For free ideas on how to get started, see www.crestawards.org

Managed by

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