Australia's National
Science Agency

Dance with a digital human

Teacher Resource: Years 1-9

Contents

About CSIRO's teacher resources

CSIRO, the national science agency, has been delivering high-quality STEM education and outreach programs and initiatives for Australian teachers, students and the community for over 40 years.

We are proud to support National Science Week and teachers with curriculum-aligned learning activities for Year 1 through to Year 9 students.

This collection of activities has been prepared in conjunction with Australian-based educators. While activities include an indication of what learning stage they may be suitable for, teachers are invited to see these as recommendations and modify the activities as appropriate for their circumstances and students' needs.

About Dance with a Digital Human

This resource is to be used in conjunction with the Dance with a Digital Human webinar as part of National Science Week 2023. Recordings of the webinar can be accessed after the event through csiro.au/education.

The webinar showcases how technology is applied to human movement and sport science to help athletes perform at their best. CSIRO scientists cover how artificial intelligence and motion capture techniques are used to transform real humans into "digital humans".

About Digital Humans

CSIRO researchers have developed a markerless motion capture system called the Digital Human. A digital human is a computer model of the body that tracks movement of joints using machine learning algorithms. It might show how you move, where forces are high or low in your muscles, or even how you chew food. Because we can't see inside our bodies, we need to use models that help us understand what is happening. These models are always getting better as we learn more and make better technology to look inside the body (like MRI).

The technology has been applied to enhance dive mechanics and ergonomics in the workplace. The team are working to apply the technology to a range of other solutions, including other sports.

Innovation is driven by collaboration. To innovate in this area, we need an understanding of:

- human biology/physiology
- physics, bio-mechanics and levers
- data, Artificial Intelligence and Machine Learning to train a machine to recognise human joints
- Responsible Innovation – diverse datasets to ensure innovations are not biased, engage with ethics, impacts and ensure widespread benefits.

The links between health and Digital Humans *(covered in the webinar)*

Our overall health is strongly linked to how and when we move:

- When we move around like walking, playing sport, doing work, and playing games it can make our bodies healthy and stronger.

- Every time we move a body part, like an elbow or knee, the muscles get longer and shorter to push against our bones. These forces enable us to stand up, run, or lift things.

- Our body responds to these movements and forces by making our muscles stronger and less likely to get injured, improving the health and strength of our bones, improving the hormones in our body and brain, and using energy. All these things are great for our physical and mental health.

Lots of people do not move enough and miss out on those benefits. Sometimes, the body responds in a negative way.

- Muscles and bones can get weaker, some may develop obesity, diabetes, and poorer mental health, or cannot do fun things when they want to.

- Also, sometimes we move badly, and get hurt. This could be from falling over or accidentally hitting ourselves on something. This can result in an acute injury. Sometimes the cause of the injury is obvious, and we might be able to prevent them happening in the first place (i.e. mopping up a spill to prevent a slip).

- However, sometimes we get hurt from movement and it isn't from one event. We might call this a "chronic" or "overuse" injury. This used to be called a "repetitive strain injury" or "RSI".

One way to improve movement-related issues is to measure movement, but this is not always easy. Current methods require very expensive equipment, expert technicians, and can be difficult to use.

An easy and cheap method for measuring movement could help us to:

- understand the cause of overuse injury and reduce how many occur.

- understand how much we move and if we need to move more.

- motivate people to move – such as by making fun computer games that encourage us to get moving.

Further reading

- Digital Human (csiro.au)

- Athletes launch in to their best dive with Data61's Dive Mechanic

- How digital humans are helping Australian athletes

- Digital Ergonomics

- The Virtual Mouth

Class activities: Years 1 & 2

General discussion points

Discuss:
- What does the word digital mean?
- What does the word future mean? When we're talking about the future, what is important to consider?
- What is power?

The push and pull effect on the body

Watch this video outlining push and pull forces. Discuss how different body parts move to do various actions while students dance.

Visualising push and pull

Draw some parts of the body that need to push or pull to move. Draw the direction the limb/s move when you stand up, raise a hand to our shoulder, nod our head, shrug our shoulders.
Note: Some parts may do both so allow students to explore these different options.

Investigating push and pull

Investigate: Working in pairs or small groups, and using at least five different objects, video each other pushing and pulling objects on the ground, in the air and through small dishes of water. Watch the videos of the movement and create a table of how the body had to change to make the object move.

Object	**Did we use push or pull? Draw the body part that used this.**	**Did the object change? If yes, how?**	**How the environment effected the push or pull of the object.**
Toy boat	*My arm muscles pushed the boat. I had to push it to go through the water*	*It got wet but didn't change shape.*	*The water was easy to push through.* *The water was easier than the ground to push through.*

Extension: Move the objects differently and compare what muscles did when the object was moved slower or quicker. Compare how a leg might move an object instead of a hand and what this does differently.

Moving safely at school

Investigate: Discuss all of the different reasons we need to move safely at school. Look at ways that we can move safely at school to ensure we don't harm ourselves (i.e. trip over or pick up heavy bags in the wrong way) and we don't harm others (bumping into others).

Discuss: What are some things that stop us from moving safely at school? (i.e. distractions like mobile phones, wet floors, pushing crowds).

Innovate: Design or draw something that can help us to move safely around school so that we look after our bodies and bodies of other people.

Push and pull dance off

Watch a video of the 'Digital Human' (available shortly after the webinar at csiro.au/education) as a group. Pause the video when the group notices a push or a pull movement. If this is difficult for younger students, educators can create a series of movements to show the class (i.e. pushing hands away as we touch the four corners of the box in the dance.)

Follow a set sequence from a section of the video (or teacher created if needed) that involves the body pushing and pulling objects (that can be real and/or imaginary) and move our body in different ways.

Create a push and pull sequence with or without objects, showing the best way to move their bodies in a sequence they devise. Encourage students to name the action different limbs are making as a push or pull.

Program a digital human

Work as a group: Gather into groups of three. One partner is the "athlete" with the 'dots' on their joints (these could be sticker dots or armbands around the elbow or knee joints), one is the "digital human", and the other is the "scientist".

The "athlete" with the joint dots begins to make movements while the "digital human" copies them. The scientist observes only the 'digital human' and reports back to the athlete what they saw the computer program do. The athlete can tell the scientist if this was correct or not.

If the scientist thinks the "digital human" looks uncomfortable with a movement, they can tell the "athlete" to move their body in a better way.

Reflect as a group: How can a digital human and scientists help us to move better?

Class activities: Years 3 & 4

General discussion points

Discuss:

- What does the word *innovation* mean?
- What does the word *future* mean?
- How can we power future industries?
- How can digital humans power future industries?

The effect of forces on our bodies and objects

Discuss: How do we move when we push or pull different objects? What do our bodies do when we push different toys or objects?

Watch the video of the AFLW player warming up (available shortly after the webinar at csiro.au/education).

Pass a ball in different ways with the hands or feet.

Discuss: What do our muscles do when we stretch in different ways?

Investigate: In small groups, pass a ball in different directions and ways. Take turns videoing each other using the ball.

Use a table to record findings: How does a leg move differently depending on the type of push we give the ball? How does the arm need to move for a long or short pass, a bounce or a tight hold?

Action with ball	**Description of what my body did.**	**Push or pull**	**Reflection on movement**
Short fast throw	*My muscles lengthened and shortened quickly. My body had to move side to side quickly*	*Push*	*The fast push helped the ball to travel quickly and to through the short distance.*

Which forces help us play by the rules?

Watch the video of how science is helping athletes: The Digital Athlete

Using this list of traditional Aboriginal and Torres Strait Islander toys and games, have students investigate which forces help us to play games fairly and safely.

First, work out how to play the game. After playing it, list the contact and non-contact forces needed for this game to work well.

Name of the game	Contact forces & body use	Non-contact forces & impact	How these forces help this game to be fair and safe
Apwerte	*Gentle push force on ball with arms and hands.* *Gentle Push force on knee to bend* *Friction of grass will slow the ball down.*	*Gravity ensures the ball will land.*	*Gentle push force helps the ball to stay in the area and not harm others.* *Gentle knee bend stops injury.*

Extension: How do forces play an important role in various games? Consider favourite games and the forces that make it a successful game to play.

Eating with force

Watch the video of the Virtual Mouth.

Investigate which level of force is needed to break down various foods.

Work in pairs and watch how different food needs to be chewed to be broken down, how different food moves around the mouth, and which teeth have the most force placed on them at various times.

Explore the behaviour of the food in the mouth, and how it impacts where, and how we chew the food. Draw up a table that notes different parts of the mouth and what they do for different food.

Mouth part	Observation - write a description & draw an illustration. *i.e. they/it moved up and down, it was squished, it was hard to see at times, things got stuck etc.*
Tongue	
Teeth	
Lips	

Follow up activity: Write a recommendation for dentists of how they could use this technology or write a letter to a food technologist outlining how some foods may need to be modified to support good mouth health.

Digital helpers

Watch the video of the Digital human (or webinar).

Discuss: How this video help us to understand how our bodies move?

Consider: What if we had something to help us move well all of the time? What if we could have a digital helper that can tell us when we are moving in ways that might injure us.

Innovate: Brainstorm an invention to help people move their bodies safely and carefully around the school, home or outside.

Draw what this digital helper would look like, label the different parts, and write an explanation of how it works, how it can be programmed and any problems it could have.

Focus on Tech

When researchers are creating or coding computer programs, they need to tell the programs what to do next. They do this using commands (conditionals) like 'if', 'then', and 'end'.

Show the class a movement with the following words: "If my arm moves like this, then my leg will do this."

Investigate: Have students consider the words 'if' and 'then' and how they play a role in moving our bodies.

List different finger, hand or arm movements and predict what might happen to different parts of the body when they move and complete as a class.

Use a table to record findings: List different leg parts: toes, ankle, knee & hips, predict and then investigate.

Body Part	**Prediction**	**Investigation result**
If I wiggle my wrist up and down…	*…then I think my elbow will move*	*My fingers flopped around and they were hard to keep still.*
If I take a big step forward on my right leg…	*…then my left leg will bend at the knee*	*I wobbled. My left leg did bend.*

Class activities: Years 5 & 6

Group investigation

Watch the video or attend the webinar of the Digital Human and conduct one or more of the following investigations using the scientific method of inquiry. (Video to be made available shortly after the webinar at csiro.au/education).

Scientific method for teachers to follow: Working scientifically

Title	Jointly discuss the outline of this investigation to formulate the project title
Aim	Jointly discuss the purpose of the investigation
Prediction	Students create their own prediction of the expected outcome of the investigation
Equipment	Joint discussion
Risk Assessment	Joint discussion with reasons
Method	Listed procedure of how investigation is intended to take place.
Results	Listed outcomes alongside sketches, diagrams, tables, graphs and photos
Reflective conclusion & discussion	Students write down what they learnt, what worked well, what they would do differently next time

Investigating movement

How can we move more and move better at school?

Innovate: Design a series of activities or games that show how to move the body properly and more often, so we do not injure ourselves. Have students consider games that can be played to encourage the practice of these movements and movement of the whole body for health.

Discuss: How can this investigation at school be used to inform how we get adults to move more often? Trial the investigation at school to work out how people respond to different activities.

Design a prototype

After watching how scientists look at our bodies in the laboratory (i.e. using the Digital Human), think about how people can use this information/research so they can improve simple things like posture while walking or while using a computer.

Consider how we can be more aware of our daily movement by designing an AI tool that would be inexpensive, non-invasive (not distracting to learning, small enough to wear) and informative (i.e. look at a robot vacuum and how that moves around a room, mapping it to know where it has cleaned, or consider a smart watch that helps to track movement and heart beats for inspiration). Refer to this fact sheet.

Long term research: Movement and its role in our mental health.

Design an experiment with the following question in mind: how does movement play a positive or negative role in our daily learning?

Explore this by looking at how we move around different places such as the home, classroom, our office, our playground, shopping centre, sports field etc. Work out how we move differently in these areas and how these different types of movement play a role in how we learn. This research can be conducted through interviews, observations and tests.

Eating with force

Watch the video of the Virtual mouth.

Conduct an investigation to determine which level of force is needed to break down various foods from a variety of food groups.

Investigate: Work in pairs to watch how different food needs to be chewed to be broken down, how different food moves around the mouth and which teeth have the most force placed on them at various times.

Explore the behaviour of the food in the mouth and how it impacts where and how we chew the food. Consider how we can make healthier food easier to eat - with a focus on how it is eaten.

Moving a basic digital human

Using the pivot animator website, look at the different joints in the stick figure and how they are used to move limbs.

Consider the joints in the body and how moving one part of a limb may make another part move (i.e. while keeping the elbow still and moving the forearm, the muscle in the upper arm tenses.)

In pairs, have one student create a series of movements as a human and replicate this on the pivot animator. The partner watches the pivot animator and then copies the movement in real life to see how it feels. Then swap places.

Reflect on how seeing a stick figure perform movements can impact how the body moves.

Teach a machine

Use Google's Teachable Machine to upload images of different human poses, and see if the computer can recognise them.

Extension: Create an online machine learning model to identify the direction of head movement using pose detection. Refer to this Teachable Machine tutorial.

Are you a Rembrandt or a Monet?

Use Google's Art Selfie app to see how Machine Learning can work out which famous portrait from the past looks like the students.

Class activities: Year 7 - 9

AI for Citizen Science

Listen to the *AI and Citizen Science – AI in Ecology* episode of the Everyday AI podcast (available on Apple and Spotify)

Consider and discuss: After listening, think about how citizen scientists helped support these different forms of AI. Discuss in pairs, comparing ideas and reasons behind the thinking. Share these ideas with the group and consider how AI can be helpful.

Extension: Download a citizen scientist app such as the Merlin Bird app, the iNaturalist app or Frog ID.

Spend at least 15 minutes outside every day for a week recording different sounds, collecting samples or taking photographs.

Reflect on this week by considering these questions:

- How quickly was the information found?
- How easy was it to navigate the technology?
- Which living things were known to be in the area before using the app?
- Which living things came as a surprise?
- How accurate was the AI and how easily did it narrow down the possibilities of these living things nearby?

Collate and graph the data and that of others and share with the class after a weeks' worth of collecting.

Discuss similarities and differences between the data and consider where each data set was found.

Using AI in sport

Listen to the *Data, numbers & AI vision – AI in sport* episode of the Everyday AI podcast (available on Apple and Spotify)

Consider and discuss: After listening, think about how AI could be used in sport to support athletes of all abilities. Discuss in pairs, comparing ideas and reasons for the thinking. Share these ideas with the group and consider how AI can be helpful to increase diversity in sport participation.

My own Digital Human

After watching the Digital Human webinar, recreate a digital human video for their own class context. Consider the key messages they need to convey to their classmates about healthy movement as a year 7, 8 or 9 student in their school. Remember to take the specific school context and environment into account.

Fitness plans

Using the ideas from the Digital Human webinar, create a series of fitness videos that help students to move in the correct way so they can build strength, agility and fitness.

Consider creating an outfit to show how joints move during different activities so that viewers understand the correct technique.

Compare movements

Investigate: Using a working scientific method, investigate how students move to dance or play sport, like the digital human. Test if there are common traits in these movements.

Compare student movements to those of athletes to work out if peers are moving correctly to avoid injury.

Using your results, come up with a series of activities to support the area of movement that most students have difficulty in.

Further reading:

- Using digital humans for diving
- Artificial Intelligence for Science report
- Look, but don't touch: Digital Humans and performance analysis

Education@csiro.au
csiro.au/education
facebook.com/CSIROeducation