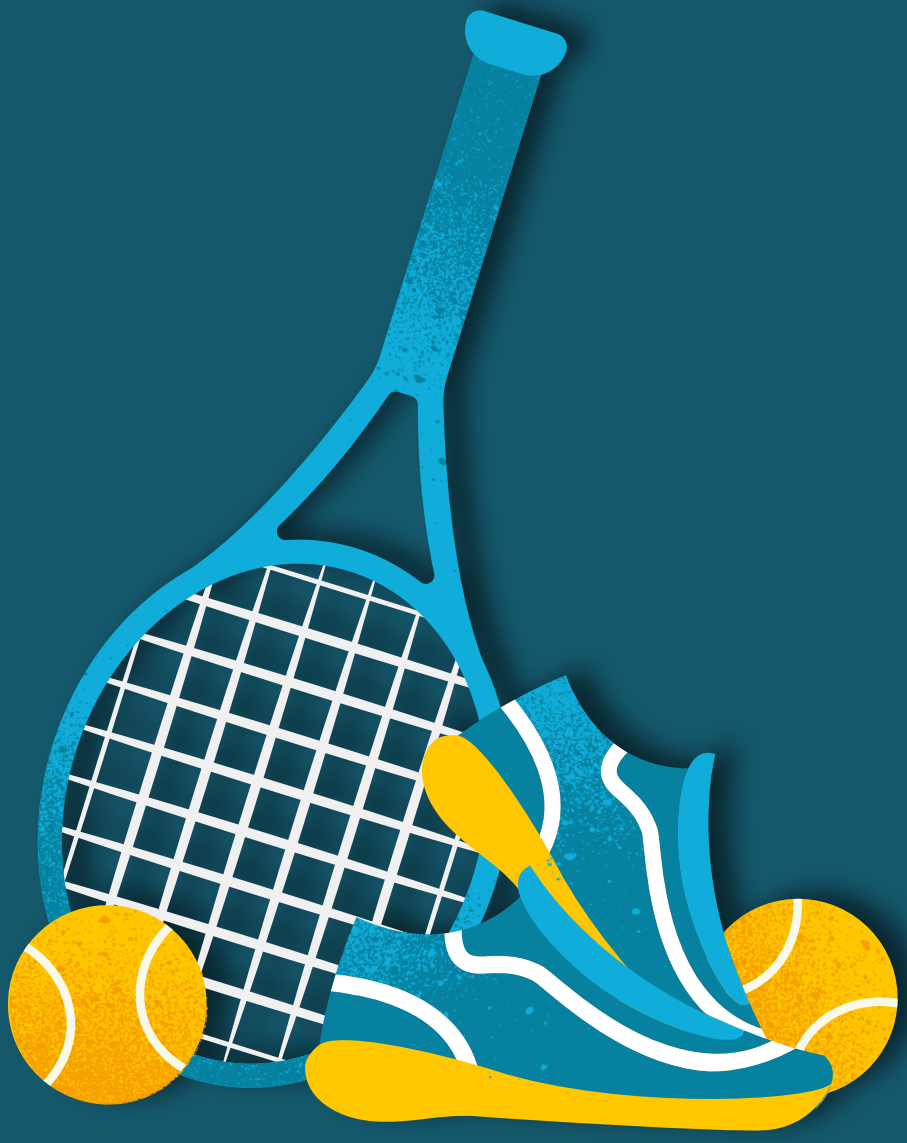
STEM CLUBS

NUMBER 1 FOR STEM

A STEM FUTURE: SUITABLE FOR STUDENTS AGED 11-14

How can we enhance sporting performance?

STEM Learning activity resources



SUBJECT LINKS:

Chemistry, design and technology, physics, maths and essential skills.

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Introduction

This programme has been created by STEM Learning, the largest provider of STEM education and careers support in the UK. It has been developed in partnership with Club leaders and supports essential employability skills and the Gatsby Careers Benchmarks.

How can we live smarter?

Ready, set go! Playing sport is a fundamental part of our society, but how will it change in the future? Which new technologies and innovations will help us to get the most out of our favourite activities?

This programme investigates how you can use **science, technology, engineering and maths** to enhance how we play sport – from programming a Micro:bit to test tennis serves to creating a sweatband that stays dry no matter how much you sweat!

Digital and Essential Skills

Throughout this booklet, activities highlight skills sets that can be enhanced by taking part. This enables pupils to further develop both digital literacy and competency in desirable key skills. These highlighted skills allow the pupils to focus on specific aspects to achieve notable progression. If other skills better suit your club members on a particular activity, then focus on that skill.

Key information

AGE RANGE: 11–14

SUBJECT LINKS: chemistry, design and technology, physics, maths and essential skills.

DURATION: a range of activities up to 60 minutes each – 6 hours in total.

FLEXIBILITY: complete the whole programme over a half term or choose individual activities to suit the needs of your club.

RESOURCES: Each activity includes a list of the resources required and a comprehensive set of club leader and student notes.

ESSENTIAL SKILLS: Age-appropriate essential skills have been identified which can be enhanced through these activities.

IMPACT MEASUREMENT: Each set of resources is designed to help evaluate and assess the progress of Club members. A free student assessment toolkit can be requested from: STEMclubs@stem.org.uk.

ACHIEVEMENT: Students can be rewarded for successfully completing activities by downloading free STEM Clubs certificates from https://www.stem.org.uk/stem-clubs/impact-and-recognition/stem-club-certificates. Students may be able to use these resources to work towards a CREST Award.

APPROPRIATE VENUES: Club leaders can run most activities in general spaces e.g. classrooms, halls, and outdoor areas. Some activities need to be conducted in labs and workshops – these are marked clearly in the Club leader guide and in the table below.

SAFETY: Each activity includes details about health and safety considerations. Club Leaders should ensure that all equipment is handled with care, particularly sharp instruments. Advice and guidelines are available from CLEAPSS and SSERC. We recommend that practical activities are risk assessed before commencing and Club Leaders should follow their employer or organisation's policies.

OTHER ACTIVITIES: Discover other exciting STEM Club activities: https://www.stem.org.uk/stem-clubs/activity-sets#secondary

STEM CLUB SUPPORT: Find lots of ideas, support, training and advice at: https://www.stem.org.uk/stem-clubs

Activities

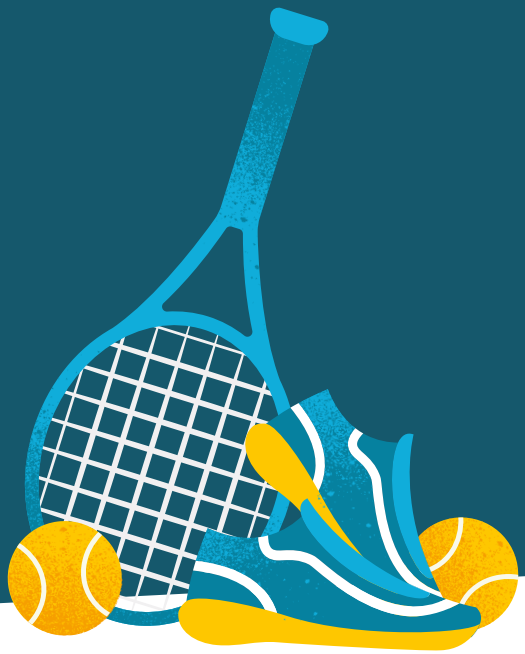
STEM CLUBS

NUMBER 1 FOR STEM

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

1 The "never wet" sweatband



Objective

In this activity students extract the polymer sodium polyacrylate from a nappy and explore how it interacts with water.

HEALTH AND SAFETY:

A suitable risk assessment must be carried out by the activity leader and any significant findings recorded: if carried out in schools, guidance from CLEAPSS or SSERC must be used where appropriate. Protective eye wear should be worn. Students should avoid breathing in powder from the nappy.

TOPIC LINKS

- Chemistry: polymers
- Design and technology: smart materials
- Engineering: application of material to solve a problem

ESSENTIAL SKILLS SUPPORTED

Listening, creativity, teamwork

TIME

60 minutes

RESOURCES AND PREPARATION

- Disposable nappies – (3 per group) (use different brands to compare absorbency)
- Scissors
- Beaker (3 per group)
- Small clear bags (e.g. sandwich bag)
- Water
- Safety goggles
- Stirrer (to mix the polymer and water)

DELIVERY

1. Discuss what happens when students do sport on a hot day. How can being hot make sport more difficult?
2. Ask students to consider what sort of things sports people use to combat sweat?
3. How could we improve the current design of a sweatband. What would make it better?
4. Hold up a nappy for inspiration. Can students make the link?
5. Introduce the idea of smart polymers and how they can be used in many scenarios.
6. Assist students as they gather their polymers, following the student guide instructions.
7. Encourage students to think outside the box – where else could we use this technology? What are its limitations?

DIFFERENTIATION IDEAS

Support: remove the powder from the nappy before the session. Help students get the correct quantity of water to the powder.

Challenge: provide cloth such as old towels or cotton and make prototype sweatbands, make sure they are the same size and use the same amount of polymer. Conduct absorbency experiments.

TIPS

- make sure your work surface is clean as you want to scoop up any stray bits of polymer.
- keep the neck of the bag narrow when you're blowing into it – it will make filling it easier and prevent the powder from blowing into your face.

EXTENSION IDEAS

1. Ask students to consider if the temperature of water makes a difference. How could they find this out?
2. Try adding salt to the gel. What happens? Why do students think this is?
3. What complications need to be overcome when using this technology elsewhere (e.g. a sweatband)?
4. What else could this technology be used for?

Idea!

Request a STEM Ambassador to talk about how they use new technology in their job.

Incorporating Digital Skills

Consider:

- **Why not video the experiments?**

STUDENT GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

1 The "never wet" sweatband

Your challenge

Our sports people aren't underperforming but their sweatbands are! You need to use modern technology to revamp the sweatband so it keeps dry for longer.

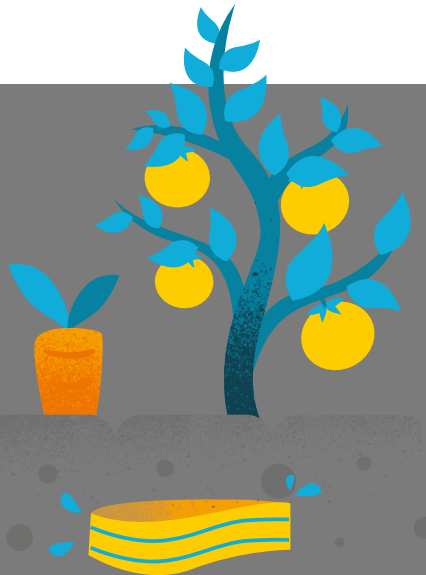
YOUR TASK Adapt a sweatband using technology from nappies!

WHAT YOU NEED TO DO

1. Open up one (clean!) disposable nappy and carefully cut through the inside lining to expose lots of cotton.
2. Remove the cotton and put it into a clear plastic bag. Add any stray powder (that's your polymer) to the bag too.
3. Blow a little air into the bag and then seal it (be careful – you don't want the powder blowing into your face).
4. Shake the bag for a few minutes to separate the powdery polymer from the cotton.
5. Carefully remove the cotton from the bag, leaving behind the powdered polymer.
6. Add the polymer to a beaker.
7. What happens when you add water? How much water can it absorb? Can you turn your beaker of water upside down with no spillage? Makes notes on how much water you add and how long it takes to absorb until you can safely turn the beaker upside down.
8. Carry out the same experiment with the other nappies and compare results.
9. Where else could this technology be used apart from sweatbands?

FUN FACTS

1. These super absorbent polymers are also used in gardens. They're loaded with water and put into the soil and slowly release water when roots need it. Imagine being able to use this technology in areas of the world that experience drought.
2. Lots of sports equipment uses polymers, for example, nylon. Nylon is used to make clothing comfy with a snug fit and helps to support muscles.
3. Ever seen fake snow? That's also sodium polyacrylate!



STEM CLUBS

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CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

2 Sensational rock climbing

Idea!

Request a STEM Ambassador to talk about how they must adapt in their role.

Incorporating Digital Skills

Consider:

- Use of online videos as research.
- Why not video the experiments?

Objective

In this activity students mimic the climbing abilities of a gecko by exploring how the properties of a polymer change as the ratio of ingredients change.

TOPIC LINKS

- Chemistry: polymers
- Engineering and design & technology: manipulating a polymer to suit a specific purpose

ESSENTIAL SKILLS SUPPORTED

Listening, staying positive, teamwork

TIME

60 minutes

RESOURCES AND PREPARATION

- Borax solution (4% w/v in water: LOW HAZARD)
- Water
- PVA glue
- Measuring cylinder
- Two disposable cups
- Stirring rods
- Tape, glue, glue sticks
- Safety goggles
- Alternatives to borax solution: bicarbonate of soda or saline solution

HEALTH AND SAFETY:

A suitable risk assessment must be carried out by the activity leader and any significant findings recorded: if carried out in schools, guidance from CLEAPSS or SSERC must be used where appropriate.

Protective eye wear should be worn.

Students should safely dispose of their polymers at the end of the session.

Slime with borax should not be taken home by students.

DELIVERY

1. Discuss how animals are adapted to their surroundings. Which animals are particularly good at climbing walls and why is this?
2. Explain that scientists and engineers often use nature as a point of inspiration for problem solving.
3. Show students a clip of a gecko climbing walls (see Useful links below). Ask students how it sticks to the wall and discuss how it defies gravity.
4. Introduce the ideas of surface area and adhesive. Scientists know there are millions of tiny hairs on the bottom of a gecko's foot possibly covered in a sticky adhesive.
5. Ask students how we could use this biological phenomenon to our advantage. Could we adapt this to suit human needs? What factors would we need to consider? How are our needs different to a gecko's?

TIP

Have spare disposable cups available so that students can trial out different ratios more easily.

DIFFERENTIATION IDEAS

Support: give students specific quantities to use or assign different groups specific ratios so that the resulting polymers can be compared.

Challenge: allow students to experiment through trial and error to independently come up with a successful ratio.

EXTENSION IDEAS

1. Get students to predict how they could change the ratios to get their polymer to stick for longer.
2. Explore techniques for loading the polymer onto a climbing shoe.
3. Ask students to come up with complications they will need to overcome to use this technology on a shoe.

USEFUL LINKS

- A National Geographic video showing how geckos stick to walls
  https://video.nationalgeographic.com/video/00000156-b855-dbd5-add6-bbf73cc70000
- BBC Earth: Geckos have super powers
  http://www.bbc.co.uk/earth/story/20151128-geckos-can-run-on-ceilings-and-thats-just-the-start-of-their-skills

STUDENT GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

2 Sensational rock climbing

Your challenge

Climbers aren't satisfied with cliff faces – they want to be able to climb across ceilings too! Geckos have always been a source of inspiration for wall climbers. What coating could we add to climbing shoes to climb like a gecko?

YOUR TASK Use trial and error with borax, water and glue to create a coating that can be thrown and stuck to a screen but can also be peeled off.

WHAT YOU NEED TO DO

1. Add some PVA glue to a plastic cup – you can decide how much glue.
2. Add an equal amount of water to the PVA glue.
3. Now add some borax solution to the PVA/water mixture – again, it's up to you how much. And keep up the mixing!
4. What happens when you add the borax solution? What have you made?
5. Experiment with different ratios of the borax–PVA/water mixture to create a polymer that you think will be sticky enough to hold itself on vertical glass.
6. Set up a safety screen to test your polymer. You should also wear disposable gloves and safety googles or glasses.
7. Make sure your polymer has set properly. If so, you're ready to throw it from a set distance at the screen – does it stick in place?
8. Hold a competition to see who has the stickiest polymer – the one that sticks the longest wins!

or if using bicarbonate of soda and saline solution

1. Add some PVA glue to a plastic cup – you can decide how much glue.
2. Add an equal amount of water to the PVA glue.
3. Add a pinch of bicarbonate of soda and a few drops of saline solution.
4. What happens? What have you made?
5. Experiment with different ratios of PVA/bicarbonate of soda/saline solution to create a polymer that you think will be sticky enough to hold itself on vertical glass.
6. Set up a safety screen to test your polymer.
7. Throw your polymer from a set distance at the screen – does it stick in place?
8. Hold a competition to see who has the stickiest polymer – the one that sticks the longest wins!

FUN FACTS

1. This polymer was found by accident! An engineer was trying to make a cheaper version of rubber and accidently dropped some boric acid (similar to borax) onto his bench materials. Which later became silly putty!
2. PVA glue is made of polymers, which are like long strands of spaghetti. Borax contains sodium tetraborate – which joins the spaghetti strands (polymers) together creating a much more rubbery and solid material than the PVA glue was: these are called cross links!
3. Borax was found in Tibet in the 8th century and is used for its cleaning properties in laundry powders and detergents!
4. The toy industry relies heavily on scientists and engineers. Making 'slime' is a common activity kit that you can buy for children. These polymers need to be cheap to make, safe to handle and look cool!

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CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

3 Smart trainers

Idea!

Request a talk from a STEM Ambassador in the field of sports science.

Incorporating Digital Skills

Consider:

- Use of online videos as research.
- Why not video the experiments.
- Use of 3D CAD and CAM.

Objective

In this activity students work in a design and technology lab to heat plastics and observe how they react differently. Students will explore the properties of different plastics, comparing thermoplastics with thermosetting plastics.

TOPIC LINKS

- Chemistry: polymers
- Design and technology: properties of plastics
- Engineering: investigate materials to improve performance or product

ESSENTIAL SKILLS SUPPORTED

Listening, problem solving, teamwork

TIME

60 minutes

RESOURCES AND PREPARATION

- A variety of thermoplastics (e.g. packaging found on toys, Easter eggs, chocolate boxes or plastic cups with PS on the bottom)
- A high-powered hair dryer or a hot-air gun or a plastics oven
- Hot gloves/heat resistant gloves
- A vacuum former if available
- A variety of thermosetting plastics (e.g. HIPS, wire insulation, polythene rod)
- Safety goggles

HEALTH AND SAFETY:

A suitable risk assessment must be carried out by the activity leader and any significant findings recorded: if carried out in schools, guidance from CLEAPSS or SSERC must be used where appropriate.

Protective eye wear should be worn.

Plastics should be clamped in place in a vice and not touched as they will remain hot for a long time. If any concerns in using a hot-air gun, a plastics oven can be used as an alternative.

This activity requires support from a specialist design and technology teacher.

DELIVERY

1. Discuss ways we could enhance sporting performance. What might limit sporting performance in the Olympics?
2. Could enhanced sportswear make us run faster, jump higher and throw further than we ever have before?
3. Why are there so many different trainers available? Ask students to think about what design features would make the ultimate trainer.
4. Get students to test how different plastics react to heat.
5. What if all trainers were an exact fit to the person's foot? A layer above your skin?
6. Once students have investigated how different plastics react to heat, demonstrate how vacuum forming occurs. Allow students to have a go and encourage them to think about how this technology could be applied to SMART trainers.

TIPS

- This activity needs to be done in a design and technology workshop in collaboration with a design and technology club leader.
- Give students the Useful links below to help them with their research into the uses of 3D printing.

EXTENSION IDEAS

1. Ask students some of the following questions:
   - do all the plastics change back at the same rate
   - what happens when the plastic has cooled
   - how could this idea of remoulding be applied to a trainer
   - where else could this technology be used
2. Ideas to try:
   - students could create a mould of their own foot to form the perfect trainer
   - students could research how 3D printing and CAD/CAM could be applied to this idea

DIFFERENTIATION IDEAS

Support: categorise the plastics into thermoplastics and thermosetting plastics. Ask students to heat each set and compare the impact heat has. Give the students a mould to vacuum form around.

Challenge: give students a variety of plastics and allow them to experiment with heating to independently categorise them into thermoplastics and thermosetting plastics. Get students to predict what the plastic will do before they heat it. Students cut a mould of their own footprint from MDF and create a unique insole for their trainer.

USEFUL LINKS

- BBC Bitesize clips of new CAD and CAM technologies www.bbc.co.uk/education/topics/zhv8q6f/resources/1
- BBC Bitesize video of the uses of 3D technology www.bbc.co.uk/education/clips/zpnkqty
- BBC Bitesize video of the uses of 3D technology in the fashion industry www.bbc.co.uk/education/clips/z9t87ty

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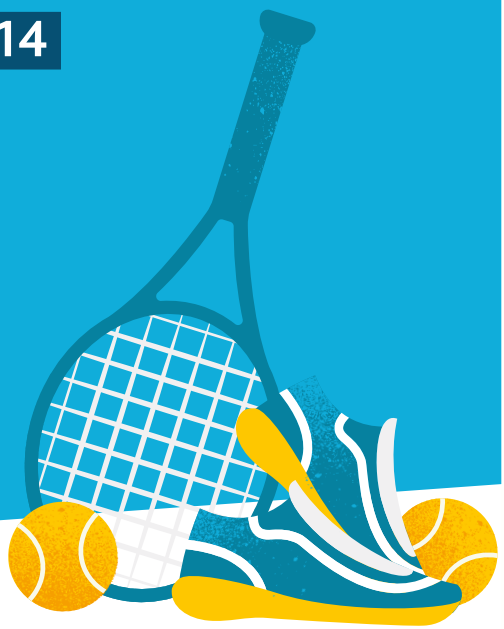
How can we enhance sporting performance?

3 Smart trainers



Your challenge

Having trainers that are the perfect fit can allow us to run faster, jump further and train for longer. Unfortunately, as everyone's feet are different, the trainers you buy are never going to fit perfectly. Now imagine trainers that could mould to your feet! We'd first need materials that can change their shape.

YOUR TASK **Explore how we can mould plastics using heat.**

WHAT YOU NEED TO DO

1. Select a plastic and secure it in a clamp stand or vice.
2. Ensure the area around your plastic is clear.
3. Begin to heat the plastic. You'll need to get it really hot!
4. What do you notice? Does the plastic melt or does something else happen?
5. Try the same with a thermoset plastic. What happens?
6. Have a look as your club leader creates a shape by vacuum forming around a mould. Could this technology be applied to smart trainers? Think about what you have learned about plastics –what properties would you want the material to have?
7. Research the use of 3D printing and CAD/CAM (your club leader may have some links to start you off).
8. How could you apply these techniques to develop your smart trainer? Would you use all of them, or one over the other? Why?
9. Create a final design for your smart trainer, justifying your production process.

FUN FACTS

1. The idea of moulding a plastic to a certain shape isn't a new one: the ancient Egyptians used to use tortoise shells as moulds to make bowls!
2. The word 'plastic' comes from the Greek plastikos, meaning 'capable of being shaped and moulded'.
3. One recycled plastic bottle would save enough energy to power a 60-watt light bulb for three hours.
4. Design engineers are constantly updating how they mould plastics – to consider how they can recycle more and cut energy input needed – making their products more sustainable than ever!

STEM CLUBS

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

4 Keep yourself cool

Idea!

Request a STEM Ambassador to host the discussion about how our bodies react to temperatures and what we can do to help.

Incorporating Digital Skills

Consider:

- Use of Tinkercad Circuits to simulate the thermistor circuit.

Objective

In this activity students build simple circuits incorporating thermistors. Students will explore how a thermistor works and how an alert can be set if temperatures get too hot.

TOPIC LINKS

- Physics: circuits
- Design and technology: electronics

ESSENTIAL SKILLS SUPPORTED

Problem solving, aiming high, teamwork

TIME

60 minutes

RESOURCES AND PREPARATION

- 4mm leads
- Thermistor (negative temperature coefficient, e.g. 4.7K Ohm)
- Crocodile clips
- Bulldog clips
- Light bulb/motor – a component that will visually react to a change in current
- Multimeter
- Beaker (1 per group)
- Water
- Kettle
- Thermometer (-10°C -110°C)
- Power pack (5V, DC)
- Clamp, stand and bosshead

HEALTH AND SAFETY:

A suitable risk assessment must be carried out by the activity leader and any significant findings recorded: if carried out in schools, guidance from CLEAPSS or SSERC must be used where appropriate.

Protective eye wear should be worn.

Ensure wires are clipped away from the hot water and that care is taken when pouring and measuring.

DELIVERY

1. Discuss what happens to body temperature during a workout. Does body temperature stay constant? Elicit that it is constantly fluctuating and that this can cause problems in the wardrobe department.
2. Hold up a thermistor and ask students if they recognise it. Explain that it will change the amount of current in a circuit depending on how much heat is applied to it.
3. Discuss how a thermistor could be useful when doing exercise.
4. Allow students time to select materials for their thermistor circuit.
5. Assist students as they plan and make a simple circuit with a thermistor, following the instructions on the student guide.
6. Students can think about how their circuits could be applied to clothing.

TIP

Add paper to the motor to turn it into a fan. This way, students can make the direct correlation between the stimulus (body temperature rising) and the response (fan turning on).

DIFFERENTIATION IDEAS

Support: give students the exact materials needed for the circuit only to help with their build.

Challenge: allow students to select their materials from a variety of wires/bulbs/thermistors/crocodile clips and get them to independently build a circuit where a motor responds to heat change.

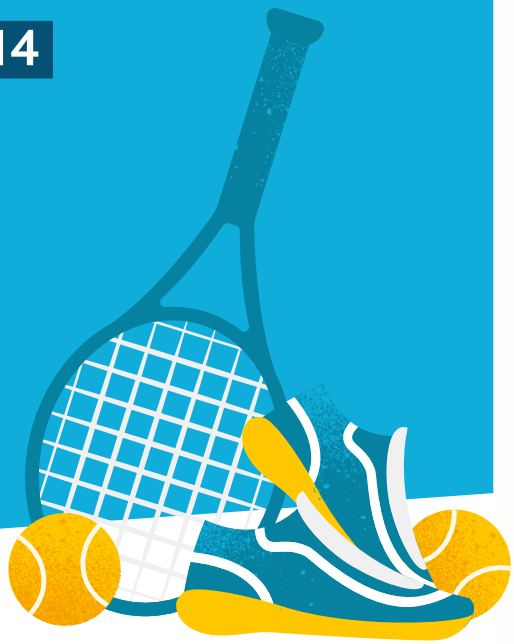
EXTENSION IDEAS

1. Get students to add a fan to their motor so they can see how this technology can be applied.
2. What range of temperatures do students' thermistors work between? Are all thermistors the same?
3. Allow students to experiment with a variety of thermistors
4. Ask students to try experimenting with the thermistor using heat from their bodies rather than the water. What do they notice about the difference in voltage?
5. How will this affect the thermistor they use when designing smart sports gear?

STUDENT GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

4 Keep yourself cool



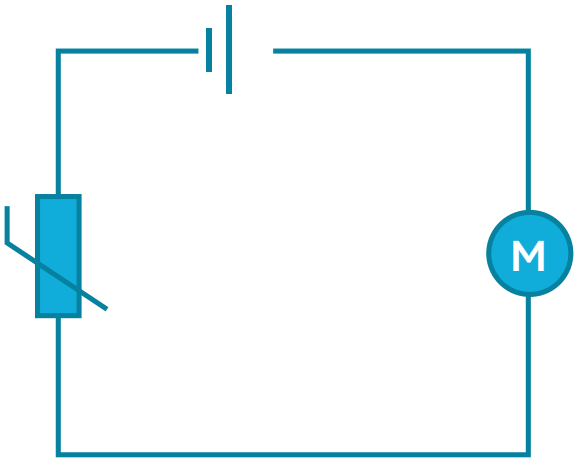
Your challenge

We have breathable sportswear, but what about smart sportswear? Could sports clothing tell how warm you are and then change to keep you cooler so the clothes are actively respond to your needs?

YOUR TASK **Design a circuit with a thermistor and create a way that this could be applied to clothing to make it respond while you're wearing it.**

WHAT YOU NEED TO DO

1. Set up a circuit as illustrated in the diagram. You will notice that your motor does not turn on as the resistance from the thermistor at room temperature is too high.
2. Half-fill a beaker with hot (not boiling) water.
3. Put the thermistor into the water. Clip the wires to the side of the beaker.
4. Record the temperature of the water and the voltage of the motor.
5. Measure the temperature of the water and the voltage around the motor at set intervals as the water cools down. Record your findings.
6. What is happening to the voltage? What do you notice about the motor? What do you see happen as the water temperature gets cooler? Why is this?
7. Consider what you have learned and how you could apply this knowledge to sports wear.
8. Design a way to apply a thermistor to materials to make them smarter. What factors about sports and humans will you need to consider?



FUN FACTS

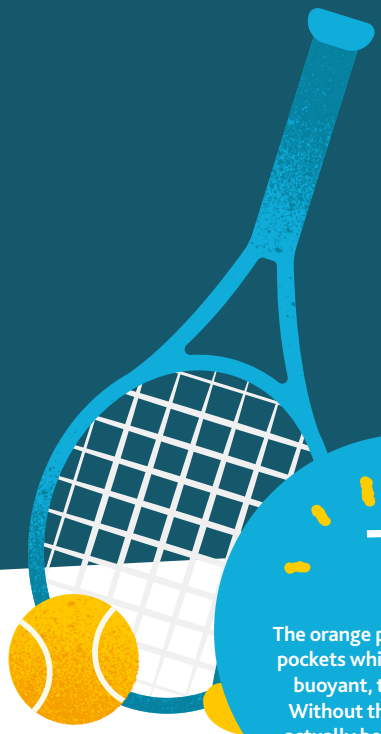
1. Did you know thermistors are used in microwaves? They ensure the temperature inside a microwave stays constant, preventing overheating and protecting us from exploding appliances!
2. Physicists save lives! Incubators used for premature babies are essentially a giant thermistor: keeping an ambient temperature that mimics the womb.
3. You need different types of thermistors (made from different metals) to regulate different temperature ranges. For example, for temperatures below -150^{0}C, you'd need a thermistor made from germanium, but for higher temperatures you'd need to make the thermistor from a metal oxide.

STEM CLUBS

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

5 Lie back and float



TIP

The orange peel contains tiny air pockets which make the orange buoyant, therefore it floats. Without the peel, the orange actually becomes denser than water and sinks.

Objective

In this activity students explore the buoyancy of different fruits. Students will learn that increasing mass sometimes results in enabling an object to float rather than causing it to sink.

TOPIC LINKS

Physics: density

ESSENTIAL SKILLS SUPPORTED

Listening, problem solving, teamwork

TIME

60 minutes

RESOURCES AND PREPARATION

- Large beaker or bowl
- A variety of fruit that can be peeled (e.g. grapefruit, orange, satsuma, lemon, lime, banana)
- Digital scales
- Wetsuit or wetsuit material

DELIVERY

1. Ask students the following questions:
   - Who can tread water?
   - What's the longest you can tread water for?
   - How can we make treading water easier?
2. Elicit that the material of wetsuits can potentially be altered to make the users more buoyant.
3. Demo: ask students whether they think an orange will sink or float in the beaker of water. ask a volunteer student to try it out and try to get the orange to sink. They can't – it always floats.
4. Ask students to think of a way to get that particular orange to sink. They are not allowed to add anything to the orange to get it to sink.
5. Reveal the solution. Ask a student to peel the orange – now what happens? Hand out the orange peel and ask them why this is happening.

HEALTH AND SAFETY:

A suitable risk assessment must be carried out by the activity leader and any significant findings recorded: if carried out in schools, guidance from CLEAPSS or SSERC must be used where appropriate.

Take care when peeling the fruit.

This activity may be more suited to a lab environment due to the use of water.

Incorporating Digital Skills

Consider:

- **Use of video to record experiments.**

Idea!

Request a talk from a STEM Ambassador in the field of sports science, focus on how our bodies use energy.

DIFFERENTIATION IDEAS

Support: demonstrate as above and let students experiment with other fruits.

Challenge: Use the displacement method to measure the density of the fruits in g/ml. Compare these to the density of water (1 g/ml) and predict which fruits will sink and which will float.

EXTENSION IDEAS

1. Ask students what happens with other fruit? Why do we not get the same results?
2. Ask students to try adding salt to their water – how does this change things?

STUDENT GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

5 Lie back and float

Your challenge

Treading water is an essential skill for water sports, but it's tiring and uses up energy. How can we make materials more buoyant to reduce the energy lost treading water during water sports?

YOUR TASK **Experiment with fruit and model your wetsuit on an orange for maximum buoyancy.**

WHAT YOU NEED TO DO

1. Watch the demonstration.
2. Calculate the density of the fruits in g/mL and the density of the water to predict which fruits will sink or float.
3. Set up your own beaker of water and try the experiment with other fruits.
4. Select one fruit at a time and check if it floats or sinks.
5. Peel the fruit. Test whether they float or sink and compare to the predictions you calculated at the start of the activity.
6. Compare the peels of the fruits to explain your results.
7. What else will affect whether the fruit floats or sinks?
8. Consider how a wetsuit works, how could you improve the design or the materials used.

FUN FACTS

1. Some fruits that look similar, like lemons and limes, act very differently. This is because their densities are so different: limes are denser than lemons and so hold more juice. To extract maximum juice, try warming up the lime in the microwave first – it makes a huge difference!
2. Archimedes discovered the idea of buoyancy in his bathtub! King Hieron II had asked Archimedes to solve a problem: was his crown made of pure gold or had he been cheated and some silver has also been mixed in? Archimedes got some pure gold of equal weight to the crown and measured the amount of water it displaced. When he did the same with the crown, it displaced less water, proving the crown was indeed not pure gold. This led to the "eureka!" moment we all know so well!
3. Things are more buoyant in salt water – that's why everyone floats in the Dead Sea. It has such high salt content that things that normally sink, float.
4. Materials engineers will use the idea of buoyancy to develop cool new materials to help people like deep-sea divers. It's all about understanding the core science and then applying it to solve a problem.

STEM CLUBS

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

6 Keep calm and dry

Objective

In this activity students make a material waterproof by different methods and test for breathability. Students will explore ways that we can coat materials to make them waterproof and design a test to find out which method is most successful in terms of waterproofing and breathability.

TOPIC LINKS

- Chemistry: hydrophilic/hydrophobic
- Design and technology: materials

ESSENTIAL SKILLS SUPPORTED

Presenting, problem solving, aiming high

TIME

60 minutes

RESOURCES AND PREPARATION

- Cut offs of material (10cm x 10cm)
- Beeswax
- Unscented tea candles
- PVA glue
- Alum powder
- Linseed oil
- Clean cloth
- Hair dryer
- Pipettes
- Water
- Paintbrushes
- Safety goggles
- Oil and water (demo only)

HEALTH AND SAFETY:

A suitable risk assessment must be carried out by the activity leader and any significant findings recorded: if carried out in schools, guidance from CLEAPSS or SSERC must be used where appropriate.

Protective eye wear should be worn.

Take care when handling hot wax and hot water.

TIPS

- Ensure the material you are coating is completely dry to begin with. It will be coated with substances that are hydrophobic so the coating will not work if the material is already wet.
- The alum powder method requires two hours of soaking, then drying. The linseed oil method requires drying overnight. Students can do this but it may be worth having pre-soaked and dried versions of these ready for the testing phase. Alternatively, students can prepare the materials one session, and test them the next session.
- If you don't have a hairdryer to soften the beeswax, set up a Bunsen burner with a tripod and white tile on top. Place the beeswax on the tile and it will soften as the tile warms up. The cloth can be warmed in the same way.
- Oil, wax or PVA glue waste should be placed in refuse bins, only residue on surfaces/objects should be washed off with detergent and disposed of down the sink. Ideally wipe residue with paper towels and place in bin.

DELIVERY

1. Discuss with students what problems sportsmen and women encounter training outdoors in the UK. How do we deal with the rain? Does it stop us from training/exercising? How could we get around this?
2. Explain that there are ways we could modify our clothing to make it waterproof.
3. Demo: use oil and water to introduce the terms hydrophilic and hydrophobic.
4. Show students a variety of waterproofing materials (PVA glue/wax/laundry detergent/oil etc.).
5. Ask students what these coatings might do to the breathability of the materials. What impact will breathability have on the wearer?
6. Support students as they waterproof material in different ways.
7. Task each team to devise a test to ascertain which coating is best in terms of breathability and waterproofing.

At the end of the session teams should present their findings and compare results.

DIFFERENTIATION IDEAS

Support: give students access to instructions for how to waterproof and explain how they could test for breathability and waterproofing. For example, fill a test tube with 15ml of water and use an elastic band to secure the material tightly over the top of the test tube. Use a straw to blow into the test tube. If the material is breathable, students will clearly observe condensation on the inside of the test tube above the water level. Turn the test tube upside down to test how waterproof the material is.

Challenge: allow students to research waterproofing methods prior to STEM club and bring their own ideas to the table. Alternatively provide students with equipment that could be used for testing (test tubes, straws, flexible pipe) and ask students to collaborate to come up with a way to test the waterproofing methods to find which is most breathable. Allow students the freedom to play with the materials and equipment to independently come up with a method of testing.

EXTENSION IDEAS

1. Once the best method has been selected, look closely at how it is done. Could the method or ratio of ingredients be altered to make it even better? Give all students a chance to fine tune the winning waterproof and breathability method.

Idea!

Invite a STEM Ambassador who works in materials engineering to talk to students.

Incorporating Digital Skills

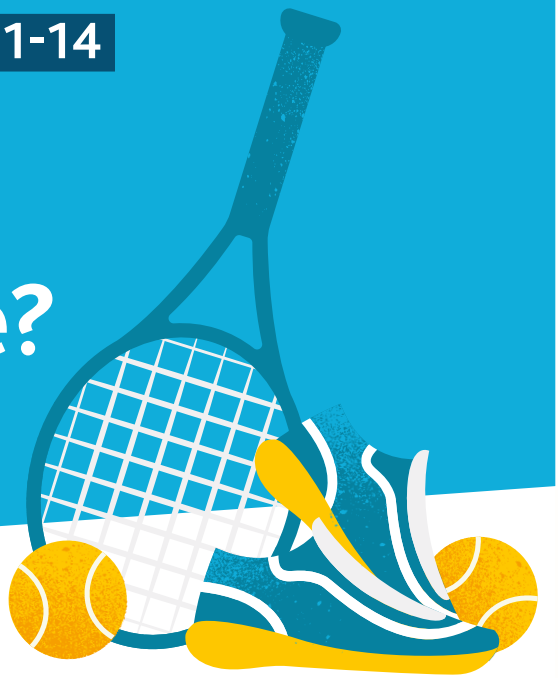
Consider:

- **Use of video to record process to review later.**

STUDENT GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

6 Keep calm and dry



Your challenge

Lots of sportswear needs to be waterproof and performance can be compromised if we get too wet and uncomfortable. How can we keep our sports people dry?

YOUR TASK

Experiment with different ways to waterproof materials and test to find out which one is most waterproof and breathable.

WHAT YOU NEED TO DO

Choose how you will waterproof your material based on the selection your Club Leader has provided – which do you predict will work best?

PVA glue

- Mix equal quantities of PVA glue to water.
- Use a paintbrush to add a thin layer to your material.
- Leave the coating to dry.

Beeswax

- Use a hair dryer to soften the wax (don't melt the wax).
- Warm the cloth with the hair dryer too.
- Use the cloth to rub the warm wax onto your material, coating evenly.
- Once the material has been covered, use the hair dryer to reheat the thin layer of wax, melting it into the material.
- Leave the coating to dry.

Tea candles

- Remove the candle from the foil tin and discard the wick.
- Run the candle directly onto your material, leaving white marks where wax has been applied.
- Once the material has been covered, use the hairdryer over the material, melting the wax in.
- Leave the coating to dry.

Alum powder

- Make a solution of 80g of Alum powder in 250ml of hot water.
- Let your material soak in the solution for two hours (you may need to weigh it down with a glass bottle).
- Remove from the solution and hang to dry.

Linseed oil

- Use a paintbrush to apply a layer of linseed oil to the material. Don't worry if there seems to be a lot of oil.
- Wait 15 minutes and use a tissue to wipe off the excess oil.
- Hang the material to dry.

Devise an experiment that will test each coating for breathability and waterproofing. Record your results and consider how you could improve them. Present your findings to the other teams and compare results.

FUN FACTS

1. The first waterproof jacket was invented by Charles Macintosh, blending a fabric with rubber. His name was adopted for all raincoats in the UK, and is still used today!
2. The very first waterproof jackets made by humans are thought to have been made from seal intestines.
3. The greatest challenge to making a material waterproof is allowing it to be breathable too. It's one thing keeping someone dry, but we don't want them drowning in their own sweat!
4. Bob Gore was an American engineer and scientist in the 1960s who went on to develop Gore-Tex, the most famous breathable material on the market today.

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

7 Get CREST Discovery Awards

By completing all six activities in this resource pack, your STEM Club members can get a CREST Discovery Award.

ABOUT CREST

CREST is a scheme that inspires young people to think and behave like scientists and engineers. It is student-led, flexible and trusted. CREST helps young people become independent and reflective learners. With no set timetable, projects can start whenever you want, and take as long as you need.

HOW TO GET YOUR CREST DISCOVERY AWARDS

It's easy to get your members' Discovery Awards, simply:

1. Sign-up for a free account - https://my.crestawards.org/
2. Have each member complete a CREST Awards Discovery Passport
3. Create a project eg. "How do they make movies", "Movie music" or "Witchcraft and wizardry"
4. Upload names
5. Upload two or three passports and any accompanying work
6. Assess individuals, have they:
   a. Completed around five hours of work on the project?
   b. Participated fully in the project?
   c. Reflected on their learning?
7. Type in your delivery and payment details.

TAKING THEIR WORK FURTHER

If members want to take activities further, they can work towards a CREST Bronze or Silver Award.

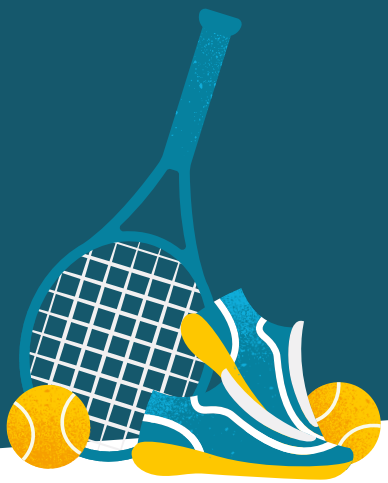
CREST Bronze Awards require around ten hours of enquiry, project-based work, and Silver Awards require thirty hours of work at GCSE or equivalent standard. Using one of the activities for inspiration, they choose a question or topic to investigate.

Guidance on how to run CREST Bronze and Silver Award projects is available on the CREST Awards website www.crestawards.org.

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

8 The Skills Builder Framework



Skills Builder FRAMEWORK

The Activities and Employability Skills

Each activity within this resource pack has identified the essential employability skills it supports and develops in students.

These skills have been mapped to the essential skills identified by the Skills Builder Framework, which breaks down eight essential skills into 16 teachable and measurable steps. Club leaders and teachers can use the activities to promote good practice and enhance each student's individual learning curve. Helping to promote transferable skills key to their education and future employment.

ABOUT THE SKILLS BUILDER PARTNERSHIP

The Skills Builder Partnership brings together educators, employers and skills-building organisations around a common approach to building eight essential skills. Their programmes include training and resources, supporting schools and colleges to embed a rigorous approach to building skills and achieve the Gatsby Benchmarks. As an individual teacher or Club leader, you can freely access a suite of online teaching tools and resources, designed by their team of teachers to build essential skills. The suite includes learning activities, supporting videos, classroom resources, assessment tools and the Skills Builder Framework, which you can use in STEM clubs and classroom teaching.

THE SKILLS BUILDER FRAMEWORK

The Skills Builder Framework breaks down eight essential skills into 16 teachable and measurable steps, providing a common set of expectations and a roadmap for progression. Step 0 is for the least experienced learners and Step 15 represents a highly skilled adult. The Framework can be used by teachers and Club leaders to talk to students about their skill strengths and areas for development and is a useful tool for framing conversations about careers and employability. Focusing student learning through the Framework, enables students to recognise their own essential skill levels and work to master them over time. The Framework can provide a language for students to articulate this progress to helping to develop employability skills and prepare students for future careers.

Skills Builder also provide multiple online assessment tools, including a student self-assessment, student-by-student teacher assessment and class- level formative assessment through the Skills Builder Hub. This means that programmes can be differentiated and focused to meet individual needs.

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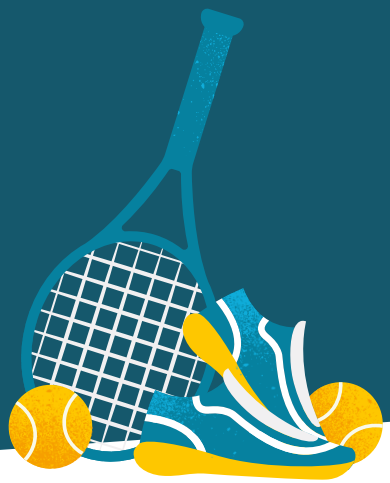
8 The Skills Builder Framework



EIGHT ESSENTIAL SKILLS

The eight essential skills broadly break down into four domains we know both teachers and employers value.

Communication

1. Listening – ability to listen and understand information.
2. Speaking - vocal communication of information or ideas.

Creative Problem solving

3. Problem Solving – ability to find a solution to a complex situation or challenge.
4. Creativity – use of imagination and the generation of new ideas.

Self-Management

5. Staying Positive – ability to use tactics to overcome setbacks and achieve goals.
6. Aiming High – ability to set clear, tangible goals and devise a robust route to achieving them.

Inter-personal

7. Leadership – supporting, encouraging and motivating others to achieve a shared goal.
8. Teamwork – working cooperatively with others towards achieving a shared goal.

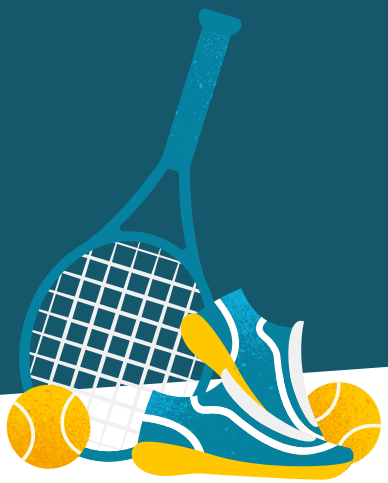
You can find out more about essential skills and the Framework on the Skills Builder website, https://www.skillsbuilder.org/framework and you can access resources on the Skills Builder Hub https://www.skillsbuilder.org/hub

You can find additional support and information on careers and employability skills on the STEM Learning Careers pages, https://www.stem.org.uk/ stem-careers. You can also download the free Skills Builder toolkit from the STEM Learning website https://www.stem.org.uk/rxfum6

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

How can we enhance sporting performance?

8 Digital Skills



UNDERSTANDING DIGITAL SKILLS

Digital Skills are the product of digital literacy that we are all emersed in, especially within educational settings. The rapid use of digital technologies over the last 10-15 years have impacted the way we live our lives within a modern technological society.

Within this STEM Club activity, they are vast opportunities to utilize Digital Skills, which will have been taught already within the schools curricula. It's important that the use of digital skills is not meant to replace traditional methods; but enhance and further develop your students STEM learning future.

Digital skills can be grouped, recognised and celebrated.

Cross Curricula Baseline Digital Skills	Computing curriculum baseline digital literacy	Computing curriculum specific skill	D&T/Engineering specific digital skills	Science specific digital skills	Maths specific digital skills
Communication tools	Safe technology use	Digital media	Digital design (CAD)	Modelling and simulation	Modelling
Presentation	Evaluative skills	Programming	Programmable embedded systems	Sensor-enabled data collection	Data analysis / data science
Word processing and DTP	Moral, ethical and lawful behaviour	Applied knowledge of systems and networks	Digital manufacturing (CAM)	Data analysis, inference and communication	Calculation
Data handling		Modelling and simulation		Digitally enabled explanation	Graphing
Devices, tools and applications		Software development			Dynamic geometry
Productivity and task management		Data manipulation			
		Cyber security			

EXAMPLES OF USE

When conducting experiments, recording results in Excel makes it easier to present those results in a graph. This is a good example of Cross Curricula Baseline Digital Skills. Within a design and making opportunity, it would be fantastic to develop this design using 3D Computer Aided Design (CAD) and outputting on Computer Assisted manufacturing (CAM) and Rapid Prototyping (RP) such as 3D Printing. This is obviously D&T/Engineering specific digital skills.

Within the guides opportunities are signposted, these aren't the extensive list. You may find alternative Digital Skill provision. Remember you know your pupils and what equipment and skillsets staff are equipped with. This could be a great opportunity to investigate staff CPD.

STEM CLUBS

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STEM Clubs Programme, led by STEM Learning

Achieving world-leading STEM education for all young people across the UK.

For more information on the programmes and publications available from STEM Learning, visit our website **www.stem.org.uk**