The Tunnel Structures Challenge is a 'making and testing' activity where students will work in teams or in pairs to make a tunnel structure using straws, tape and scissors. At the end of the lesson the tunnel structures will be tested to see which structures survive and which don't.

Suitability Guide		
Mild learning difficulty	✔	Yes
Moderate learning difficulty	✔	Yes
Severe learning difficulty	✖	May not be suitable
Profound and multiple learning difficulties	✖	May not be suitable

Further differentiation and support needed for students with:

- Visual impairment;
- Fine motor skills delay.

Learning Objectives:

Students will learn to:
Work together as a team;

Follow instructions to create a model, or create their own;

Discover the strengths and weaknesses of different types of structure.

Activity Overview

This is a great activity for a mixed ability group as there are lots of ways to complete the challenge and many ways to participate. This version of the challenge focuses on experimenting more than competing and includes step-by-step pictorial instructions for the two different tunnel structures to scaffold the design process.

This activity can also be differentiated in a number of ways to meet your students' needs, as you can supply pre-cut straws or even create tunnel building 'kits' for your students. See Differentiation Ideas for more information.

However you choose to deliver this activity, you should supply some examples that you have built in advance. These are excellent multi-sensory stimuli that students can look at up-close and feel what they are trying to make, rather than viewing on-the-board examples or diagrams.

Skills Builder Essential Skills

In this activity students will have the opportunity to demonstrate problem solving steps 0-5 and teamworking steps 0-10. See the Skills Builder extended framework (**https://www.skillsbuilder.org/sen-old**) for more explanation.

Example Activity Plan

The plan below is just one example of how you could deliver this activity. It is based on a 90-minute session with 15 students with mild and moderate learning difficulties working in five groups of three, with a teacher and two support assistants. You should augment this plan according to the needs of the group that you will be working with. Some examples of how you could do this can be found in the section Differentiation Ideas. If you are facilitator or STEM Ambassador delivering this as a workshop and unsure about the best approach to take, then speak to your host.

Inventory

You will need:

- 1 x testing kit (see below)
- 15 x Tunnel Structures Challenge Instruction sheets, printed double sided
- 6 x bundles of 40 medium paper straws
- 1 x Tunnel Structures Challenge Presentation
- 3 x example tunnel structures
- 6 x rolls of masking tape
- 6 x pairs of scissors
- 6 x rulers
- Scrap paper

Note that the above includes enough equipment for five groups plus a spare set.

How To Assemble Your Testing Apparatus Set

To complete this activity you will need to assemble your own testing apparatus. This should include:

- Weighted bag
  - This will be dropped onto the students' models. Create your own weighted bag by filling a cloth bag or pillowcase with 2.5kg rice or sand and tying a knot or fixing with a cable tie.
- Tunnel Structures testing poster (www.hs2.org.uk/education)
  - This printed poster shows the area over which the tunnel will be built. Students should ensure that their tunnel stretches the 400mm distance between each of the tunnel entrances.
- Train
  - This will be used to test that the height and width of the tunnel is correct. Attach a toy train to a 500mm ruler with adhesive putty.

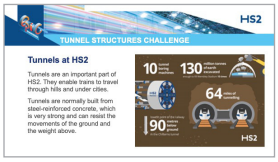
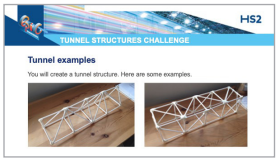
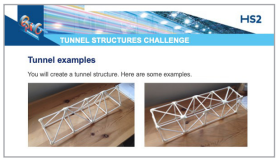
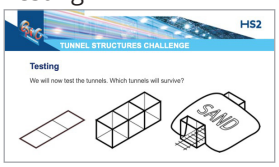
Preparation

You will require the room to be set up for tables of three, plus a demonstration table at the front of the room. Bundle or pre-cut the straws in advance of the session, and build your examples.

Sequence

Use the following sequence to plan this activity. You may wish to adjust the timings according to your style of delivery, group and workshop length.

Time (min)	Sequence	Instructions	Slides
5	Welcome and introduction 	Introduce yourself, the HS2 project and the learning objectives for the lesson.	1-2

5	Tunnels at HS2   	Using the slides, introduce the students to how and why tunnels are built at HS2. Show students the Tunnel Boring Machine video.	3-4
5	Tunnel building introduction   	Introduce Challenge 1: Tunnel Building using the presentation slide. Students will have one hour to build a 40cm long tunnel, to be tested at the end of the session. Show students the demonstration models, the materials and how the tunnel structures will be tested. Explain that students must choose between the two designs and follow the instructions or build their own design.	5-6
60	Tunnel building   	Hand out one bundle of scissors, tape and instructions to each table and instruct the students to start.	5-6
5	Tidy-up time	Students must stop making and tidy up. Unused straws must be handed back for reuse. Collect the scissors and tape. Make sure that students have marked their names on their structure.	
10	Testing  	Collect the built tunnel structures and test them on your demonstration table. Discuss the merits of each structure and test it by first checking if the train goes through, that it is of the correct length using the poster and then by dropping the weighted bag on it. Students can vote before each whether it will survive or be crushed, in a show of hands.	7

5	Plenary & careers link  	Use the plenary questions to recap the students learning. These questions refer to the learning objectives and essential skills from the beginning of the lesson. You may wish to show the Careers Video for Students with SEND and the Careers Link slide to introduce the students to careers in Construction.	8-9

Questions

Use the following questions to stimulate the students' thoughts during the session:

- Why do we build tunnels for trains?
- Why do tunnels have to be strong?
- Who builds tunnels in real life?
- How can you make sure that your tunnel structure is strong?
- How can you organise your team to build your structure more quickly?
- How can you make sure that your tunnel is big enough for the train to fit through?
- Why did you choose the design that you did?

Tips and Tricks

- This 90-minute version of the activity includes 60 minutes for the students to make their structure.
- Students have a choice of two different designs.
- The students should start with the base of their structure. This should just be a rectangle of straws that is 400mm long by 100mm wide.
- Triangular prisms are the strongest shape for their tunnel.
- The diagonal beams across the squares of the frame are called ties. These help to hold the structure rigid as they 'tie' the frame together using tension.
- Students should test their model for its stability as they build but should not be given the weighted bag. This encourages self-sabotage. Students should instead gently compress their tunnels by hand to find weak points and areas needing reinforcement.
- To prevent jeering during testing, announce that "the only acceptable response to success or failure is a polite round of applause".
- You will require 10 minutes to test for a group of 15 students.
- Count in and out all equipment to make sure that all equipment is returned. This is especially important for sharp items such as scissors.
- Watch the Engineering Challenge: Tunnel Structures Training Video (www.hs2.org.uk/education) for hints and tips that you could use in this version of the activity.
- Always brings spare straws in case a group runs out or you have more groups than you planned for.
- Give lots of praise. This activity will be challenging for some students and you should build up their resilience in case their structure gets crushed.

Differentiation Ideas

- To increase the challenge for more able groups of students do not supply the instructions, instead give them squared or isometric paper to plan.
- For less able students, encourage them to follow the instructions and customise their design when complete.
- Adjust the timing of the making part of the session according to the following:
  - If students have pre-cut straws and are following the instruction sheets, reduce the time.
  - If students have to cut their own straws and are following the instruction sheets, keep the time the same.
  - If students have to cut their own straws and are following their own design, increase the making time up to 80 minutes.
- For students with moderate learning difficulties, or difficulties with fine motor skills, you could supply modelling straws that are in pre-cut lengths of 10cm, 15cm and 40cm.
- You could put a kit of straws together for each group:
  For the cuboid frame structure, you will need:
  - 4 x 400mm straws
  - 8 x 150mm straws
  - 20 x 100mm straws

  For the triangular prism structure, you will need:
  - 3 x 400mm straws
  - 8 x 150mm straws
  - 15 x 100 mm straws.
- Make sure that the students have access to extra straws for reinforcing their structures and spaces in case some straws get damaged.
- For some students you could supply the base already made (See step two from the pictorial instructions) or the frame (step four for the cuboid frame, step three from the triangular prism). Students could be given some time to reinforce them.
- To increase the challenge for more able students do not supply the instructions, instead give them squared or isometric paper to plan.
- You could introduce a competitive element to this activity by weighing each structure with digital scales, with the lightest structure that survives being the winner.
- If you are a facilitator, ask your host to decide on which students will work together in each group. They will have a better understanding how well different students will work together and how support staff can be spread between groups.
- For groups where the making aspect of the activity would be too challenging, build a series of examples to test instead. The participation in this version of the activity would be more about discussion and deciding which structure might survive the tests, in a shorter half hour session.
- Consider testing the structures at each group's table if this will provide better visibility for the students than testing at the front of the room.
- For more able students, consider using the resources from the Engineering Challenge: Tunnel Structures Scheme of Work (**www.hs2.org.uk/education**). In this more complex version of the activity, students compete to create the most efficient structure, taking into account the weight of the materials used.

Answers

Challenge	Answer
1	Tunnel structures should be marked by their quality of making and whether they are a success. High-level work will have included diagonal ties, be taped neatly, and be the appropriate dimensions as outlined in the specification.