Biomechanics

Background, National Curriculum links and suggested aims

This lesson is intended for use when teaching the human skeleton to Years 7-9. It has been written for use in a Biology lesson.

Teacher background knowledge

No special background knowledge required for a Biology teacher. If a Science teacher with a specialism in Chemistry or in Physics teaches the lesson, there are opportunities to make links with Chemistry (e.g. properties of the various materials used to make casts) or Physics (e.g. strength of materials, including metals and bone).

Cross-curricular links

The intention is to introduce students to approaches normally used in Design and Technology. There are also links to health education.

Design and Technology curricula tend to emphasise that when designing, students should be taught to:

- use research to identify and understand user needs, including the needs of people from different cultures;
- solve their own design problems and understand how to reformulate problems given to them;
- develop specifications to inform the design of innovative, functional, appealing products that respond to needs in a variety of situations;
- develop and communicate design ideas using annotated sketches, detailed plans, 3-D and mathematical modelling, oral and digital presentations and computer-based tools.

Student background knowledge

Students should know that a bone is a living tissue and can break.

Resources and timing

No special resources.

If no extension activities are included, about 50 minutes should suffice.

Activities

The context of the lesson is a broken leg.

1. Introduce students to the four bones in the human leg (femur, patella, tibia, fibula). There is no need for them to learn the Latin names but they should know where the bones are.
2. Now, focus on the largest of these – the femur, often called 'the thigh bone', the longest bone in the body.
3. Imagine someone has broken one of their femurs. Ask students what might lead to this happening? There are several possibilities:
    a. An accident causing too large a force to be exerted on the femur, causing it to break. The accident might, for example, be because of a car or bicycle crash or in a contact sport.
    b. The result of a disease. For example, the femur might be weakened because of cancer or some other disease – e.g. osteoporosis, which becomes more common in older people, especially women.
    c. Occasionally, repetitive overuse of the leg – such as excessive long-distance running – can result in what is called a 'stress fracture' to one of the bones in the leg (though unlikely to be the femur).
4. This might be the time to teach a bit of first aid (part of health education).
   If someone has a broken leg – whether the femur or any other of the bones:
    a. Get someone to 'phone 999 and ask for an ambulance.
    b. Help the person to keep the broken leg as still as possible until help arrives.
    c. If available, apply an ice pack wrapped in a towel (or similar) to help reduce swelling.
    d. If possible, keep the leg slightly elevated with pillows or a cushion or similar – again, to reduce swelling.
    e. Don't allow the person to eat or drink anything unless a doctor or paramedic says they can. This is because they may need an operation.
5. Reinforce this first aid by getting the students to do a *quick* role play about what to do when someone seems to have broken their leg. (There are roles for the person with the broken leg, one or two first aiders, worried bystanders – possibly offering unhelpful advice, arrival of paramedics.)

6. Introduce students to how the break might be treated. The short video (2 min 20 s) at https://www.youtube.com/watch?v=1S1nrCwm1qc is one possibility; there are others available on the internet. This video shows how the bones may need to be put back in alignment (called 'reduction') and then how a metal rod may be used in treatment. After initial surgery, it is common for some sort of cast (plaster or fibreglass) to be used.
7. Get students to think why a metal rod may be used. (They can use the internet for research or think among themselves.) The key points are that:
    a. Bone is a living tissue and so breaks can be healed, but bones can rejoin in the wrong places if not helped by medical technology.
    b. Metal is strong and allows the fractured bone ends naturally to join together and heal rather than grating against each other.
    c. The metal will not react with anything in the body – it won't be recognised as a 'foreign body' and attacked by the immune system, which normally functions to repel foreign biological matter.
    d. It can be left in place permanently, though sometimes metal implants are removed.
8. Get students to think what properties a good material for a cast would have. (Again, they can use the internet for research or think among themselves.) The key points are that:
    a. A cast needs easily to be fitted to precisely the shape of the person's leg.
    b. A cast should be strong but not too heavy. (Plaster and fibreglass have lower specific gravities than do some alternatives.)
    c. The cast needs to be easy to remove, typically by (carefully) using a saw – do not try this at school.
9. Get students to think about the design features they might want for someone who has to use a wheelchair for weeks or even a few months because of a broken femur. There is a lot of literature available for you (not 11-12 year-old students) to read about wheelchair design – e.g. https://www.physio-pedia.com/Wheelchair_Design.

    Some of the key points are:

    a. Ease of movement (whether user-propelled, pushed by others or motorised) including when making changes of direction.
    b. Stability (so it doesn't tip over).
    c. Comfort for the user (seating, not too heavy if user-propelled).

d. Ability to cope with wear and tear (and think about walk-in showers).

e. Think about the ability of a wheelchair user to see and be seen.

f. Not too expensive – especially if not provided by the National Health Service / insurance.

Formative assessment opportunities

As a teacher, think about the assessment opportunities. Students should have learnt things from their work on casts (paragraph 8) that they can use when designing a good wheelchair (paragraph 9).

Extension activities

This would be an ideal starter for a small scale (two- or three-week) Year 8 or Year 9 extended project. Alternatively, it could be run during a collapsed timetable day or two at the end of the year, using the combined resources of the science and Design and Technology departments.

Wheelchair Design for Teenagers

You have been entered by your school in a competition to design a wheelchair for use by teenagers. Prepare a slides or PowerPoint presentation with your design ideas.

Work in teams of no more than three. The duration of the entire project process is 6-8 hours.

You should include:

- Research on the needs of wheelchair users;
- Research on adapting wheelchairs for teenager use (this can include primary research in the form of interviews with wheelchair users or professionals with relevant knowledge);
- Analysis of existing designs (considering key design features, cost, aesthetic features);
- Specification of your chosen design;
- Sketches and evaluation of two or three possible designs;
- Model making (either physical models or, if time and expertise permits, some CAD work using SketchUp or Autodesk Fusion 360 if available);
- Evaluation of final product;
- Final presentation.

Resource Links

- SketchUp is available freely to schools that are signed up for G Suite for Education: https://www.sketchup.com/products/sketchup-for-schools
- Autodesk Fusion 360 is available via a free 3-year educational license: https://www.autodesk.com/products/fusion-360/students-teachers-educators
- Gallery of examples:
  - https://gallery.autodesk.com/fusion360/projects/34582/wheelchair
  - https://gallery.autodesk.com/fusion360/projects/wheelchair-2
  - https://3dwarehouse.sketchup.com/model/3a131153-61fb-4bc5-b8f4-917ad5af4860/Wheelchair
- Copyright-free photographs and animations can be obtained from the internet, e.g. https://commons.wikimedia.org/wiki/File:Femur_-_animation5.gif.