EngBAM

UNIVERSITY OF BIRMINGHAM | SCHOOL OF CHEMICAL ENGINEERING

4.10.2.1 Life Cycle Assessment

Teaching Resource

This resource has been designed to support the delivery of Chemistry content to a GCSE class. This pack contains a presentation, activity ideas and a worksheet that have been developed by the University of Birmingham School of Chemical Engineering with the aim of inspiring more students to pursue a career in STEM subjects. Linking GCSE specification points to relevant examples, it is hoped to further engage students with learning by highlighting how this knowledge is applied in real life scenarios.

Slides with underlined titles contain information directly relevant to the GCSE specification. The other slides contain extension information designed to engage students with the real life application of the specification point.

Lesson Length: Approximately 60 minutes

Key Specification Points:
AQA GCSE Chemsitry - 4.10.2.1 Life Cycle Assessment

- Life cycle assessments (LCAs) are carried out to assess the environmental impact of products in each of these stages:
  - Extracting and processing raw materials
  - Manufacturing and packaging
  - Use and operation during its lifetime
  - Disposal at the end of its useful life, including transport and distribution at each stage.
- Use of water, resources, energy sources and production of some wastes can be fairly easily quantified. Allocating numerical values to pollutant effects is less straightforward and requires value judgements, so LCA is not a purely objective process.
- Selective or abbreviated LCAs can be devised to evaluate a product but these can be misused to reach pre-determined conclusions, eg in support of claims for advertising purposes.
- Students should be able to carry out simple comparative LCAs for shopping bags made from plastic and paper

Materials required:

- A3 Paper
- LCA Class Example (provided)
- A plastic bag and a paper bag

1 Starter Activity

Organise the class into groups of 4-6 and supply each group with a sheet of A3 paper. Ask each group to divide the page into two halves, we will use one half now and the other will be used at the end of the lesson. Give the students 5 minutes to create a mind map with the word sustainability in the center. Students should write down any words, themes or objects that they associate with the theme of sustainability. This activity will be repeated at the end of the session, allowing the students to review the concepts learned during the session, as well as consolidating their learning.

2 Class Example

Each student should be given a copy of the example sheet. Allow students to have a good attempt at the task for $\sim$ 10 minutes. After this time start asking around the class to see what numbers they decided on for each box, ask them for their reasoning why. Use this to fill in an example on the whiteboard so a class comparison can be referred to when going through later slides. Hand around a paper and plastic bags for visual prompts to aid the activity.

3 Plenary Activity

Place the students back in the groups they were in for the starter activity. Ask them to repeat the activity on the blank half of the A3 paper. This should help the students to consolidate the work they have done throughout the lesson. The aim is for each group's mind map to contain more technical information than the one created at the start of the lesson.

4 Slide Notes

- Slide 1 - Title slide
- Slide 2 - Starter activity
- Slide 3 - What is sustainability?
  Defines the term sustainable development and introduce the three key themes surrounding sustainability. These three themes are some of the main sustainability challenges facing the world. Ask students how growth can still be achieved without depleting finite resources such as oil, gas and metals?. Answer: If more renewable energy sources are utilised, the demand for oil and gas will be reduced. Increasing the ease at which products can be recycled will result in less metal needing to be mined and less waste being sent to landfill sites.
- Slide 4 - Introducing an LCA
  Defines what an LCA is. Explain that an LCA covers all aspects of a product's life-cycle from the extraction of raw materials, manufacture through to use, and all the way through to disposal. Emphasise the large impact that transport has in the final LCA.
- Slide 5 - How to measure the environmental impact of a product
  Ask the class by what means they think the environmental impact of a product can be measured.
- Slide 6 - Method to measure the environmental impact of a product
  Emphasise how difficult it is to accurately quantify the impact that a product has on the environment. Talk about all of the different types of impact that a product can have on the environment. Mention how important defining the scope of an LCA is. For example the wear on a lorry as a result of transporting a paper bag. There will be wear on the tyres and the tarmac, so therefore a proportion of the emissions from replacing the tarmac on the road should be allocated to the paper bag. However, this becomes very difficult to measure and the overall burden is negligible, so a clear scope for the assessment needs to be defined. The impact of emissions from the process is very difficult to quantify, therefore standard values called potentials need to be used to characterise the environmental impact.

- Slide 7 - Introduce the class example
  Students should be given approx. 10 mins to attempt to fill in the blank LCA's provided for a paper and plastic bag respectively. In each box the student should place a value between 0 and 4, with 4 having a high environmental impact and 0 having no environmental impact. Material resources references the amount of materials required for this stage (including water). Energy use references how energy intensive that stage is. Global warming emissions references how much CO2 is released from the process. Human Health / Toxicity references how harmful that process is. The scores can then be summed allowing for comparison between the paper and plastic bags.

- Slide 8 - Completing the class example
  After letting the class have a go at trying to solve the example themselves, you could start to ask members of the class what values they got. Use this class interaction to produce a completed class example on the board.

- Slide 9&10 - Class example key points
  Go through each of the points on the slide and compare them to the scores assigned during the class example, are the scores that have been assigned reasonable? On slide 10 focus on how it is the product manufactures responsibility to consider how the product will be disposed of during the design process.

- Slide 11 - Class total scores
  Ask the class what scores they got for both the plastic and paper bags on their own copy of the worksheet. It is expected that the plastic bag will result in a greater overall score. Therefore, using a paper bag would be better for the environment. However, challenge this conclusion by asking the class to consider the number of uses of each type of bag. A plastic bag could potentially have more uses compared to a paper bag that may only be used once. Thus, is the score per use for a plastic bag lower than a paper bag, therefore is a plastic bag better for the environment? Invite the class to discuss.

- Slide 12 - LCA drawbacks
  Highlight how the numbers given within an LCA are very arbitrary. Personal judgement regarding the extent of environmental impact during each stage throughout a products lifecycle. Link to how this might make an LCA unreliable as companies can twist studies to enhance marketing campaigns and avoid criticism.

- Slide 13 - Reducing the LCA score
  Ask the class how they would reduce the final LCA score. Guide the discussion to ideas around reducing the material used, utilisation of renewable energy sources, renewable methods of transport, improved efficiency of the process, recycling the product etc.

- Slide 14 - Reducing the environmental impact
  Outline the ideas on the slide as a way to reduce the overall LCA score. Try to give examples and expand on each point.
  For example:
  Point 1: Reduce the amount of raw material required by redesigning the product to reduce the amount of materials needed.
  Point 2: Decrease the processing requirement of raw materials by choosing a raw material that will need to use minimal energy to be converted to a usable resource.
  Point 3: Use renewable energy sources such as wind, solar, biomass etc to satisfy power requirement's instead of fossil fuels.
  Point 4: Design the product to ensure it can be easily dismantled so the materials can be recycled, thus reducing landfill waste or the amount of waste that needs to be incinerated.
  Point 5: Use more sustainable methods of transport by using electricity, hydrogen or bio-fuels to power vehicles where possible.

- Slide 15 - Chemical Engineers
  State that the role of a Chemical Engineer is often to improve the efficiency of systems.

- Slide 16 - Role of a chemical engineer
  Discuss the points on the slide. Emphasise that improving the efficiency of a system will often reduce the environmental impact of a product, but this is not always the case in a every situation.

- Slide 17 - Current chemical engineering research
  This slide provides an overview of some of the current research being undertaken by the school of chemical engineering. This information is designed to give some context of how real world research is directly linked to how you could reduce an LCA score. A lot of detail is not required.

- Slide 18 - More research examples
  This slide gives further research examples, again aiming to provide some context and relevance to the students.

- Slide 19 - Plenary activity
  Each group of students should still have the A3 sheet given to them at the start of the lesson for the mind map activity. Give the groups of students another 5 minutes to repeat the activity. The aim is that they will be able to add more to the mind map and the frequency of more technical language should have increased. This activity is aimed to encourage the students to consolidate the themes that they have learnt throughout the lesson.

- Slide 20 - Summary
  This slide summarises some of the key points from the lesson. Invite the students to ask any questions they may have and encourage the students to share what they have learnt during the session.