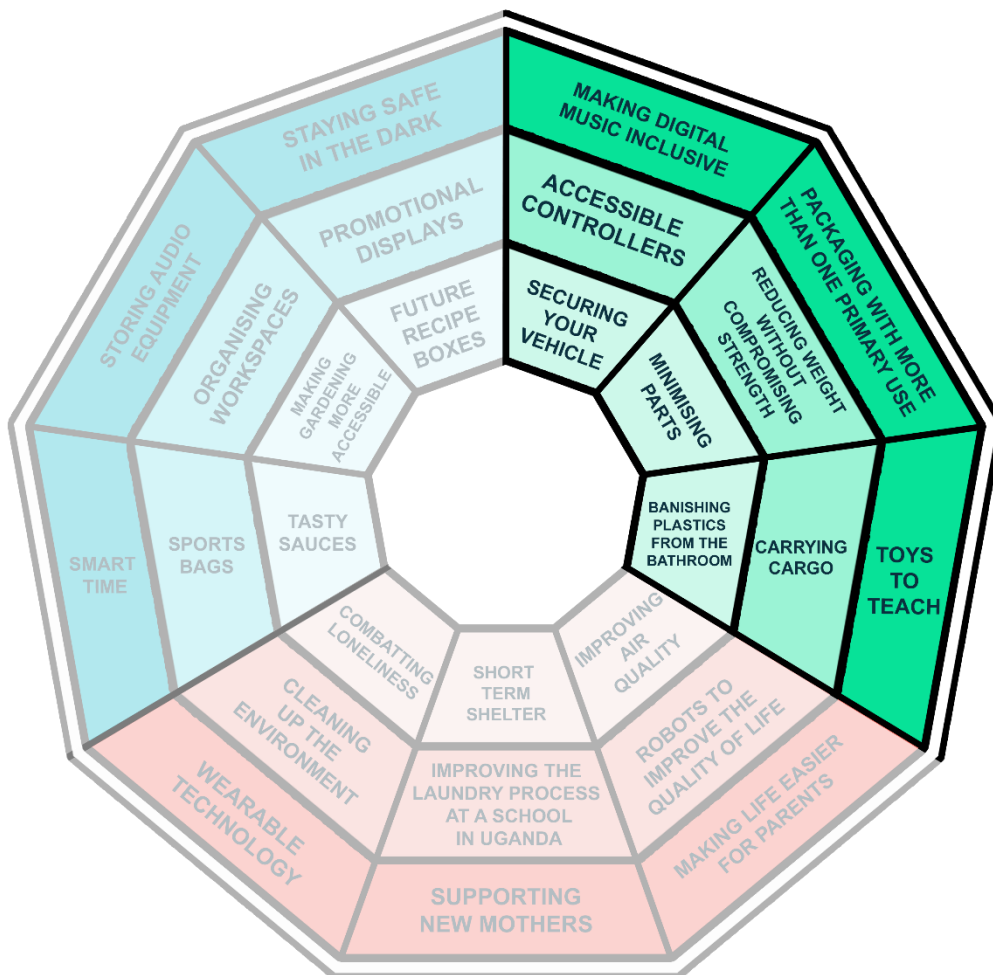


INSPIRED BY INDUSTRY

Reducing weight without
compromising strength

#InspiredbyLisi



lisi AEROSPACE
Fasteners

Introduction

This context has been put together to allow for a range of opportunities for students to explore how they can reduce the weight of an object whilst maintaining its strength. Whilst the company (Lisi) focuses on the creation of fixings for the aerospace industry, the same intent could be adapted for a range of applications where a lightweight but strong solution is required.

Materials

Because of this very open context, there is the scope to use a wide range of materials. In some ways, the exploration of a range of materials may be key to meeting the brief. There is the opportunity to look at small-scale trials of components or whole products in the pursuit of weight saving outcomes. Depending on how confident the group are, it may be advisable to constrain it to potentially one sector – such as camping, or sports, or possibly give them a small range to work in. Similarly, group work may be possible for this context. There is a good opportunity to explore 3D printing and casting in this context, and also the opportunity to engage in destructive testing and links to testing and experiments in science.

Potential outcomes

The outcomes are prototypes but will require testing in terms of their function and performance as well as being measurable in terms of size and weight. The teacher may decide to take a more conceptual route and look at a non-working prototype, exploring CAD functions such as FEA and generative design as well as comparing mass from material libraries.

It is important that students are given some freedom within this context and so outcomes should vary between students / groups. You may decide to limit your class to 2-3 outcomes as mentioned above.

Examples may include (but not be limited to):

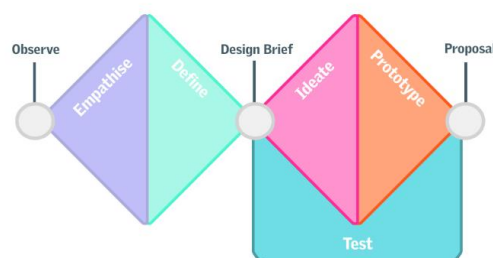
Lightweight camping equipment (chair, stove etc.), brackets/holders (storing cycles on walls, guitar stands etc), sports equipment, hooks for bags for a pushchair etc.

Consider any area of design where the outcome needs to be strong but would benefit from being as lightweight as possible. Even the most simplistic products (think of a hook for a pushchair to hang bags from) may foster great learning opportunities. Items could be 3D printed (for example) and tested with weights. It will often be the case that items will be 'over-engineered' and substantive material can be removed. This context very much showcases the concept behind this approach and it is acknowledged that 3D printing (for example) will be structurally different compared to if it was injection moulded, but provides good opportunities for constructive testing such as static vs dynamic testing (discussed later)

Consider sharing work on social media using the hashtag #InspiredbyLisi

Design cycle

The design cycle shown can be worked through in a range of orders. It's advised that the areas are revisited throughout the process depending on your time. We advise that a graphical representation of thinking convergent and then divergent may be shown to your students.



The following are some tips as to the type of activities you could do with your students.

Empathize stage

- Students should be introduced to this term if not already familiar.
- Access to users with difficulties accessing existing 'heavier' products is useful. Also consider small products – clips, brackets, hanging accessories – the importance of weight may simply be in reducing the amount of material used (especially if a finite resource) or the fact that it will contribute to transportation costs with fuel. It could be argued that the context is largely about students paying attention to finer details in products when designing.
- At the start of the context, students should be thinking wide with their thoughts, exploring the problem and not deciding too soon what they 'want to make', but observing what is happening and identifying problems.
- Trying various aspects as a group can also be useful – using and analysing existing equipment for example, then sharing thoughts and feedback.
- Whilst not the same company, this [VIDEO](#) from Red Bull shows the process that goes into making a bolt, and the subsequent importance of it. So, even if students are designing something that feels rather trivial, the impact can be significant.
- Collaboration software such as Miro, or Google/Microsoft collaboration can be good to use to collate ideas from all.
- Students should get as much information to help them later in the challenge. They may present this in any way they wish.
- When looking at 'Potential time and possible tribulations' it is an opportunity for students to look at Gantt charts and similar, to begin to plan their time and highlight any possible issues that may arise.
- Lisi have a website [here](#) that may help to show a range of their work.

Define stage

- This is where students try to get the real root of the problem and decide what they are going to do.
- There may be a whole range of problems identified. Identifying the user and their needs as well as constraints or barriers to making lighter equipment may help.
- Remember that the company uses the aerospace industry as a basis for the context, but your students can focus on any area of design they think is suitable.
- Try the 'Quad of aims' approach as shown in the slides. There are examples online that you may wish to use as [case studies](#). This may help students to create a SMART (Specific, Measurable, Achievable, Realistic, Time-bound) design brief. Using this approach may help later in KS4.
- For this stage, you may possibly constrain it to ensure students are working with materials and processes you wish to cover in the unit of work. There will still be plenty of opportunity for designs, testing, iteration etc.
- Whilst it may not be applicable at this stage initially, revisiting this and defining costs is useful. Students could create a cost spreadsheet showing savings made if 100, 1000, 1 million + were made with a new design.

Ideate stage

- For the ideation stage, you may be drawing on existing ideas (e.g., improving an existing product) rather than starting from scratch.
- Consider giving students the initial freedom of how to approach their ideas. For example, it may be CAD, a card model or a sketch. Giving students autonomy of how to approach their designs will prevent them feeling restricted. Working in groups can help generate creative ideas.
- You may wish to show students examples of where products have been redesigned to make them lighter. Examples such as these [skateboard trucks](#) and [wheelchairs](#) have been created using generative design and used additive manufacture to manufacture them, whereas some other companies appear to use this as their whole business model such as [AirGo](#).
- Consider pre-making and demonstrating/testing a few designs. For example, 3D-print some S-shaped hooks of different sizes, thicknesses and designs, and then test them by hanging weights from them. Prior to this they can also be weighed to check their mass. It may be advised to purchase a set of jewellery scales such as [these](#) that can measure small masses (or the science department may have some). Students can predict how much they will withstand, areas they feel they may break, before seeing how and when they do break/fail. This will allow students to see the potential for this context/exercise.
- Encourage students to annotate elements of their drawings – things like WHY it's that big, WHY it's that shape, WHY it has holes where it does (for example).
- A range of techniques such as 2D, 3D, Exploded and cross sections are good. It is likely that for this unit, 3D drawings may not be the most useful viewpoint for the product being designed, and instead, 2D / cross sections are more beneficial.
- CAD programs will be of great use here. Many have easy-to-use simulation elements and photorealistic rendering. Some CAD programs also have generative design which can create stronger, lighter versions of your designs.

Prototype stage

- Getting students to realise when and why to make a prototype is key. What are they looking to prove / disprove? Linking the prototype method with the problem is a good task. In the video they suggest any realisation of a design is a prototype, even small-scale trials.
- Prototypes may be mechanical or structural models, test rigs, mock ups, painted models, or CAD models and/or assemblies.
- The following are all suitable CAD programs:
 - [AUTODESK](#) free for schools/students. Mac & Windows
 - [CREO](#) free for schools/students (PC only)
 - [FREECAD](#) free for schools/students
 - [ONSHAPE](#) free for schools/students
 - [SKETCHUP](#) free for schools/students
 - [SOLIDEDGE](#) free for schools/students
 - [SOLIDWORKS](#)
- There are some good Autodesk Fusion tutorials [HERE](#) and TinkerCad [HERE](#)

- Consider asking stakeholders to give some feedback on the prototypes, as they are being developed and at the testing stage.
- Whilst the CAD models produced may be fairly simplistic in their nature, it is an opportunity to explore different techniques with students such as adding webbing, gussets, creating shells etc to replicate injection-moulded plastic components and using these elements to add additional strength. Again, you may produce some in advance to showcase the difference they can make to a product when subjected to external forces.
- Investigating properties of materials lends itself well to this context. Students will naturally test items in the next stage, and so learning about a range of properties is useful.

Test stage

- Although this is the final stage of the design cycle, encourage students to evaluate throughout and act on their feedback (and consider the feedback of others too). It is not a final thing, but a step to improve further.
- Test in as many different scenarios as possible to ensure you get realistic feedback. Observe how users are interacting with the product and use these observations to add more detail to your questions for feedback.
- Consider whether you need to test with static or dynamic tests, and show students the difference between these. This [short video](#) helps to explain, using a can to illustrate it.
- Be sure to record the testing results, either in data form, written test or use digital audio and video to record. You may wish to get students to do lab-testing (testing in the classroom) and also field testing (testing with a user).
- With destructive testing it is important to ensure safety at all times as products may react in unexpected ways. For example, if students are to test the strength of their buggy clip by hanging weights from it, get the students to attempt to write a risk assessment for the test. This will be similar to what is done in science, and ensure they adhere to all relevant PPE and safety procedures when carrying out supervised tests.
- Draw on approaches from science here. It may be worth speaking with a science colleague to replicate how students predict and record experiments. Doing this using similar methods will help to reinforce the learning.

Focused Tasks

<u>'Casting'</u>	<u>'CAD'</u>	<u>'FEA'</u>	<u>'Shape optimisation'</u>
There is an opportunity to explore different casting materials and techniques here. Demonstrate how to make moulds using vacuum forming, silicone, MDF and more. Explore opportunities to cast with materials such as pewter, Jesmonite and plaster to create outcomes and explore possibilities.	CAD software will allow you to visualise your design but also tell you of the mass of components. Use this feature to see how design changes in materials applied, and amends to the design affect the weight of the product.	You can also perform virtual testing on a product or component using Finite Element Analysis which is a feature of many CAD programs. Start with simple shapes and tests to see how the designs are likely to be affected. Consider performing the tests in real-life and compare the results.	Shape optimisation is a feature of some CAD packages they will use the virtual testing results and identify the proposed best shape for the identified test. Show students the use of this, along with the use of generative design in a variety of industries.

Investigative and Evaluative Activities

<u>'Market research'</u>	<u>'Test and rate'</u>	<u>'Generative design'</u>
Once you identify an area to develop a solution for, research the market to see what lightweight solutions are already available. If possible, obtain a range of these to test for yourself.	Once you have decided on an area of focus, look at all the solutions available and see which have reduced the weight the most. Make a chart of your results and look at the findings to see if there is any common feature to inspire your designs.	Some CAD software will let you specify an object and AI will run an infinite number of variations which can reduce materials by as much as 50% while improving strength.

