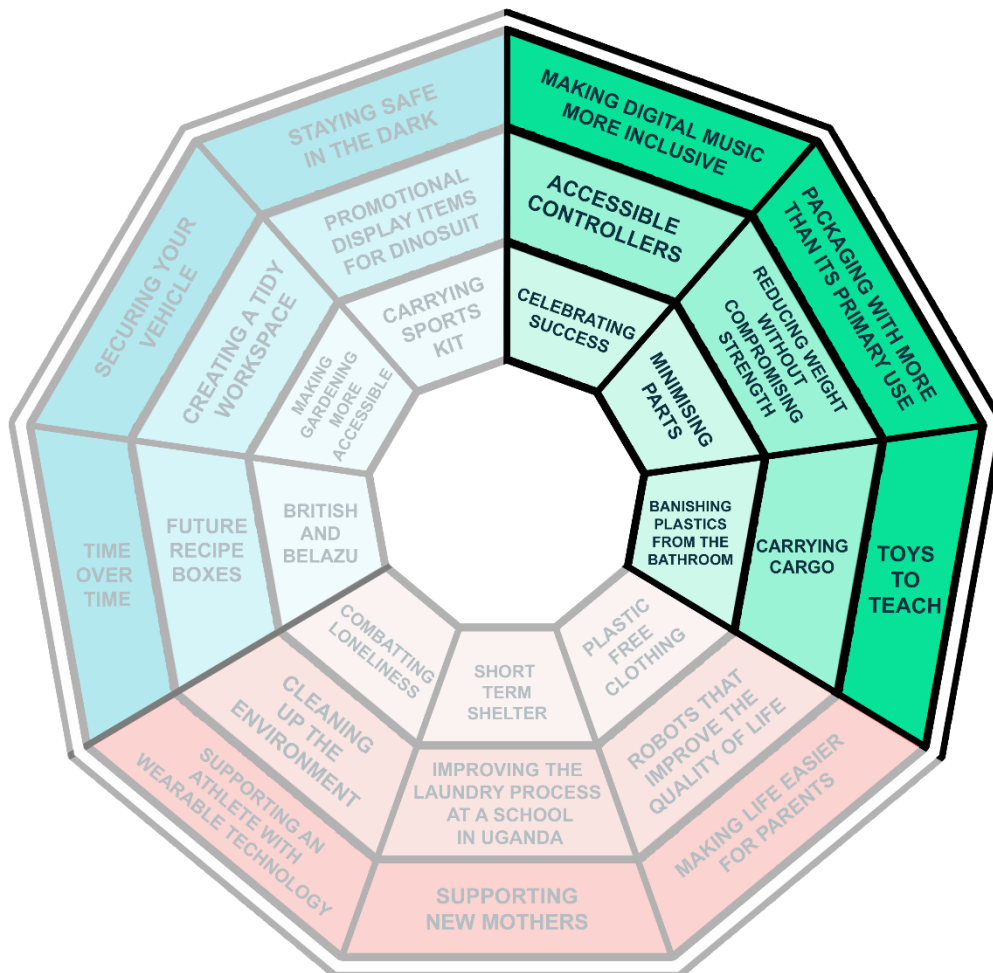


INSPIRED BY INDUSTRY

Minimising parts

#InspiredbyKI



The Furniture Makers' Company
the furnishing industry's charity



Introduction

This context has been put together to allow for a range of opportunities for students to explore how they can minimise parts in the design and production of furniture without compromising strength or functionality. Whilst the company (KI Europe) focuses on the creation of contract furniture, the same intent could be applied to any aspect of furniture design, applications or environments. KI Europe is a member of the Furniture Makers' Company (hence the dual branding) who run a student competition each year that this can help to feed into. As well as looking at traditional furniture outcomes, it opens up the possibility for a variety of approaches to the competition. Considering entering students at <https://www.furnituremakers.org.uk/young-furniture-makers-exhibition/>

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 (possibly fixings for sheet materials) or whole products in the pursuit of component or material reducing outcomes (single formed furniture?). Depending on how confident the group are, it may be advisable to constrain it to potentially one sector – such as home, or office, or possibly give them a small range to work in. This may include functional furniture to allow people to do their jobs e.g. a model-maker, jeweller, illustrator... Similarly, group work may be possible for this context. There is a good opportunity to explore 3D printing and CAD modelling in this context, and also the opportunity to engage in destructive testing and links to testing and experiments in science.

There are obvious links to manufactured boards and timbers, but also an opportunity to explore metal fabrication such as brazing. Curved lamination in card may be an inexpensive way to explore the method of bending timber, as well as QA/QC in manufacture by using jigs and formers. Fabrics have long played an important role in furniture design, and there is an opportunity to explore further here – both with accessories, but also the whole furniture too.

Potential outcomes

Although the outcomes are prototypes they will still 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 also allows the opportunity to explore scale outcomes to help with cost-saving as well as practicalities of time and space in the classroom.

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, racking etc.), multifunctional furniture (desks or storage with more than one purpose etc), lightweight portable furniture, standardised components for assembly, slot-together small-scale furniture, components and fixings to allow sheet materials to join together, scale one-piece cast furniture, new knock-down fixings, fabric additions (think holders for chairs to make multi-purpose), scale beanbag furniture, soft furnishing with scrap-fabric fill.

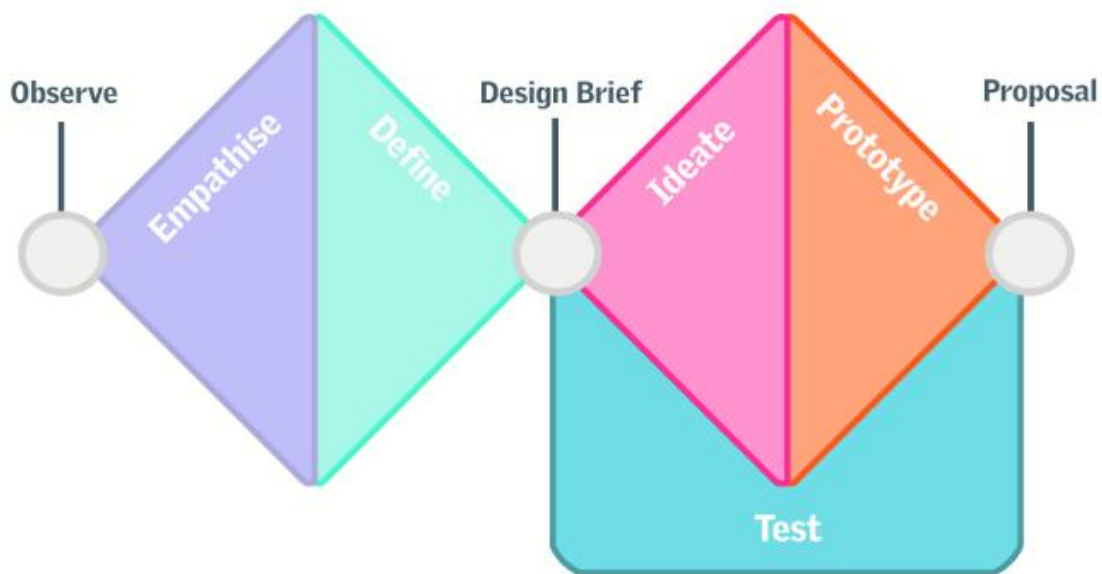
Consider any area of design where parts or weight could be minimised for cost, sustainability, functionality or practicality. Even the most simplistic products (think of a one-piece moulded chair) may foster great learning opportunities. Items could be 3D printed (for example) and tested with weights. It will often be the case that items will be 'over-engineered' and substantive material or components 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 #InspiredbyKI and as mentioned previously, taking part in the Furniture Makers' competition.

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 specific and varied types of furniture is useful. Also consider that expanding the function of a product through modular, expandable and multi-functional approaches is another way of looking at the context.
- If designing for a particular job / industry the students could study how the tasks are performed. For example, possibly inviting a local craftsperson in to explain how they work. This could be a jeweller, tattoo artist, or something completely different. Tackling an area students are not familiar with can help as they may not have any preconceived ideas.
- Consider providing a challenge e.g. how to connect the edge of a piece of plywood to a cylindrical metal piece. The challenge may be to create a fixing, rather than an entire piece of furniture.
- 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.
- 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 a range of different furniture applications it is an opportunity for students to look at Gantt charts and similar, to identify common features or attributes as well as planning their time and highlight any possible issues that may arise.
- KI have a website [here](#) that may help to show a range of their work.
- Having students assemble / disassemble flat-pack furniture is a great way to empathize for this context.

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 contract furniture industry as a basis for the examples in the videos, but your students can focus on any area of furniture design they think is suitable.
- 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, defining costs for an existing solution and then comparing it with their proposal could be useful. Students could create a cost spreadsheet showing savings made if 100, 1,000, 1 million+ were made with a new design. They could achieve these figures by calculating materials saved or the cost of components no longer needed. They may also look at the cost of

several items of furniture saved when making a product that is expandable, modular, repurposed or multi-functional.

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 furniture/furnishings have been redesigned to reduce parts or weight or to make them more sustainable. Examples such as [this chair](#) show how generative design has been used to develop solutions.
- Consider pre-making and demonstrating/testing a few designs. For example, 3D-print some simple one-piece chairs in different levels of material/structure, and then test them by applying weights to them.
- Corrugated card can simulate manufactured boards in terms of thickness, and may help to use these to produce ideas if concentrating of timber-based outcomes.
- 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), How they are proposing to minimise parts etc.
- 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. The designers themselves suggest the use of profile sketches when developing initial ideas.
- 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](#) available for schools/students
- 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.
- The assignment of actual materials to models is necessary if both FEA and generative design are to work correctly. You could use this opportunity to introduce theory of materials properties to this context.
- Scale models can be made and tested.
- Consider Augmented Reality if producing scale-models to see what they may look like in-situ. Similarly, the use of AI can apply a more completed finish to models if not produced using the 'real' materials.

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

'CAD modelling'	'3D printing'	'Stackable stools'	'In-situ'
Use CAD to create early idea concepts as well as more detailed components for working assemblies and for rapid prototyping. Encourage the idea of 'sketch modelling' using CAD.	Investigate how CAD models can be converted for 3D printing. Get students to understand the different orientation, speed of print, and other settings can affect the quality of outcome.	Students are to design a small (scale), stacking stool that can be used in school or offices. These should then be printed out and tested to see if they are able to stack safely, and easy to remove before moving onto physical models and prototypes.	Using a program such as Sketchup, design a room plan for a client of your choice. This may be an IT firm, a playcentre, restaurant, or something completely different. It helps for clients to see their furniture where it's intended, or 'in-situ'.
'Remote manufacture'		'Physical testing'	
There are few companies that design products and also have the manufacturing capabilities to make those products. Look at the processes required to design a product for remote manufacture where the products are manufactured away from the company's base and then either shipped the products directly to the buyer, or have the parts send to a factory for assembly. Explore the use of CAD for modelling, testing and creating prototype parts.		Provide students with a 3D CAD model that they can edit to make lighter / smaller and still withstand set structural requirements. Test with various weights and see the points that it bends / deforms. Plot the results in a graph and compare the results between different designs. Using models of classic chairs, discuss if the designs would have changed had they had this technology at the time.	

Investigative and Evaluative Activities

'Evolution of the chair'	'CAD testing'	'Making materials'	'Sustainable redesign'
Furniture and furnishings, like clothing, are subject to fashion and trends. Since the first records of furniture being used, chairs have evolved to take advantage of new materials and technologies as well as fashion. Investigate the history of the chair and how it evolved through the 20 th Century. Where are we now in terms of design trends and technologies?	FEA (Finite Element Analysis) is a form of virtual stress testing built into many CAD packages. Using the 3D CAD model from the focused tasks, use the FEA in your CAD package to test the model by applying forces to it.	Furniture can be made from a variety of materials, but why are certain materials used? Experiment with making your own materials such as paper pulp for casting, recycled plastic bottle tops or recycled filament for 3D printers. There are some interesting case studies online such as: https://www.kieurope.com/about-us/blog/the-next-evolution-of-sustainable-seating-postura-wood-mix-finish/	Provide a design for a piece of furniture, how can this be made more sustainable? Are students able to remove unnecessary parts, use alternative materials? They should present their design and benefits (such as costings) to an audience.

