Re-designing the paper helicopter for disaster relief

This item was submitted to Loughborough University's Institutional Repository by the author.

Citation: DENTON, H. G., 2001. Re-designing the paper helicopter for disaster relief. TIES, December 2001, pp 8-13

Additional Information:

- This article was published in the professional journal, TIES [© College of New Jersey] and is also available at: http://www.tiesmagazine.org/.

Metadata Record: https://dspace.lboro.ac.uk/2134/2265

Publisher: © College of New Jersey

Please cite the published version.
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Re-designing the paper ‘helicopter’ to support disaster area relief:
An approach to design and technology using rapid iteration and a real world context

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Introduction
This paper describes one way in which student teachers, at Loughborough University in the UK, are encouraged to approach design and technological activity. The focus is to use a quickly made, simple and reliable model, the paper ‘helicopter’ above, to iteratively explore and develop the design. This approach maximises rapid initial positive feedback (I can do this!). Pupils learn to use brainstorming, ‘what happens if?’ questions and rapid 3D modelling to explore and develop the basic design. This activity is then put into a real-world context: pupils explore whether these devices, once re-designed, could act as parachutes to supply emergency aid to disaster areas anywhere in the world. Again brainstorming and iterative modelling are used to develop ideas on appropriate performance, scale, materials and recycling. Students explore ways in which this university-taught session could be developed and applied in schools.
Some principles
1. Student teachers must learn to manage the positive growth of pupils’ self-concepts both as learners and designers. This sets pupils on a positive cycle of learning in the subject (*I can do this!*). Design, however, is a very challenging activity and it is easy for pupils to gain negative feedback (*I can’t do this – I’m no good at it*). This may start a negative cycle where pupils find the only way to develop their self-concept is in an anti-school sub-culture; as a pupil who is disruptive. Lower ability pupils, particularly, need rapid feedback, certainly within the framework of individual lessons.

2. The common model for design and technology teaching in many UK schools is via projects. These usually last several weeks and start with a ‘brief’, usually a statement of a ‘problem’, that pupils must solve. Such an approach has its value, but also limitations. In practice many designers start with an existing product and try to make it ‘better’. This may mean more effective, at a lower cost, improved aesthetically etc. We should approach some of our design and technology work from that direction.

3. Within design projects pupils are typically encouraged to spend weeks ‘researching’ and designing on paper before they handle materials. This is not the way many designers in professional practice operate, Dyson, for example promotes quickly getting into 3 dimensional modelling, often using foam. Teachers often over-estimate the value of 2D modelling and undervalue the benefits of rapid 3D modelling – especially with children (Denton 1993).

4. A basic skill for designers is the ability to ask critical ‘what happens if?’ questions. For example, if developing a kite-towed buggy, what happens if the wheel-base is longer/shorter/wider, the angle of the axles to the ground altered etc. In each case the pupil designer should attempt to predict the new performance, test the idea practically, evaluate it and then analyse why the performance changes as it does. We see links to scientific approaches and ‘fair testing’ while some questions may be aesthetically orientated, focussing on proportion, colour, textures etc.

The first iteration
This approach is taught to student teachers in a session lasting 90 minutes. The intention is that they can then apply the principles to developing school-based activity which could last anything from a single lesson to a scheme of several weeks. Similarly the principles apply to any age range and the actual activity could be used with 11 year olds or undergraduate aeronautical engineers and yet be designed to stretch the intellect at either level simply by means of the approach of the teacher and the level of analysis they demand.

Rather than long introductions the student group is gathered quickly around the centre. The staff member tells the group to watch carefully and then cuts out a pre-printed ‘helicopter’ with scissors, bending the wings and fitting a paper clip to the base. This takes about 30 seconds and makes the point that this is a quick and simple task.

‘Helicopter’ shapes tessellated on A4 paper + paperclip=  

![Image of helicopter shapes](image-url)
At this point the staff member holds the ‘helicopter’, possibly standing on a chair, and acts as if the drop the helicopter. At that point there is a deliberate pause and the question is asked – ‘what do you think is going to happen?’ Students are told to pair off and are given only one minute to decide between each pair what will happen. These responses are then shared in a whole group brainstorm. The staff member classifies the basic answers and points out that this is a ‘what happens if?’ question (a hypothesis). Before the device is actually dropped staff stretch students by demanding precision in their predictions: spin – yes – but on what axis, what direction and at what speed, etc? At this point the helicopter is dropped and all watch carefully.

The group then discuss which description came closest. The staff member asks further questions to get the group to realise that their descriptions can be more and more precise. For example: did it fall straight down, how fast did it fall, how fast did it spin, which way did it spin, on what axis did it spin what was the relationship of the wings to the vertical axis etc, how might we measure these factors? This technique can be used to differentiate within the group with more difficult questions put to brighter pupils/students, without this being obvious. This section of the exercise is used to show that there is much more to this device falling than is immediately apparent: pupils (or students) of any age or ability range can be intellectually challenged, and that the students’ descriptions can be far more precise.

The group is then given pre-printed sheets with the helicopter forms tessellated, scissors (have some left-handed scissors available) and paper clips. Within a few minutes each student should have constructed a helicopter and be ready to test it. Notice the design is simple, quick to make and it works – so giving positive feedback quickly. The group is encouraged to be accurate and produce a quality outcome, but in fact, the device works well even if cut out badly. This assists in gaining positive feedback even for pupils who may have psycho-motor problems and normally find designing and making very difficult.

The group is then gathered and told to develop a number of ‘what happens if?’ questions in their pairs. Only three minutes is allowed in order to set a brisk pace. Questions are then fed back to the whole group. The staff member can use a board/OHP to record the ideas in the form of a brainstorm/mind map. Quickly the group can be helped to see that brainstorming can generate a huge range of points to be explored, which an individual would be unlikely to develop on their own. Examples could fill pages, but could include: bending the wings the other way, increasing the number of paperclips, changing the shape of the wing – long/thin, short/fat, elliptical (keep the area the same), change the area of the wing, increase the number of wings, shortening/lengthening the vertical spine, changing the section of the wing (various options), changing the materials, etc.

Each pair is then allocated a different question to explore and then report on to the whole class. Each cycle of exploration and reporting need only be five minutes. As pairs report staff can stretch their thinking by asking supplementary questions which might then be explored in another cycle. This process can run for as long as staff consider appropriate for the age/ability range of pupils involved. An interesting area to pick-up on is the question of increasing the load. One pair may have used two paperclips and have predicted that it would fall twice as fast. Observation shows it does not, but also that it appears to spin faster. Staff can then show take the same helicopter and attach a chain of ten paper clips and ask what will happen. Most students/pupils will say that the wings will fold vertically and the device simply fall straight down. After asking for some predictions from the group the staff member checks while the whole group watch. In fact, after falling initially the device does spin – rapidly and the wings do deploy almost at 90 degrees to the vertical spine and the fall, whilst faster than with one or two paper clips is still controlled and far from a straight ‘plumet’. Analysis of this performance can be interesting and sophisticated. The role of centripetal forces in keeping the wings as close to 90 degrees to the vertical axis is interesting as is the materials technology involved.

The essential points staff need to draw out of this phase for student teachers are that motivation is raised by giving rapid feedback on the basis of a ‘recipe’ that will work. This can then be used very flexibly, depending on the age/ability range to show how designs can be iteratively explored using simple 3D models and ‘what happens if?’ questions. The group is also shown that their predictions of performance should be precise, their observation of action careful, their analysis of the change in performance detailed and this be fed back into further experimentation. Staff can also raise links to
science with the need to change one factor at a time and fair testing procedure. Staff can point out that the approach need not only be technical. We could ask ‘what happens if I colour one side of the spine red and the other yellow?’ Staff could show a helicopter where they have drawn a face on one side and two red blotches on the other side opposite the cheeks– when the helicopter falls the face appears to blush. This could then be linked to cinema principles. Above all the group is shown that they can be surprised by the possibilities of the device.

This phase could last anything from 30 minutes to two hours. In a school, pupils could use computers to design new forms of helicopter and tessellate them onto A4 sheets (CAD?). The forms could be cut out on a plotter/cutter (CAM?). A young class could be asked to design, cost out and market a range of paper helicopters to sell at a school fair, so introducing costing (possibly using a spread sheet), production (batch, production lines etc), printing (black and white, colour, possibly off-set litho etc).

The context introduced

The next step is to contextualise the approach via the following scenario: students/pupils are asked to imagine they are designers who have been asked by the Red Cross to help them improve the efficiency of their disaster relief programme. They have recognised that when dropping relief supplies from aircraft by parachute a considerable proportion of the available money is spent on the parachutes as opposed to the supplies themselves. Low level drops without parachutes cause too much damage to the supplies. The group is then told that they were at a school fair and saw the same paper ‘helicopters’ they have just worked with being sold and used. They are then asked – ‘could we explore ways in which this principle could be used to drop various emergency supplies?’

Again students work in pairs. The group is asked to brainstorm factors that could be explored. An initial five-minute session in pairs leads to a whole group feedback with staff recording in the form of a brainstorm/mind map. As ideas are put up they may provoke new ideas in others and the brainstorm grows. An example brainstormed ‘map’ is shown below.

A brainstorm on possible factors

The categories range from the fairly obvious – for example, exploring scale so that reasonably large loads can be dropped; to the less obvious. Examples include exploring re-cycling the devices after use as food, if made out of sugar or rice paper impregnated with nutrients, or impregnating them with seeds and fertiliser to provide a crop.
The age and ability range will affect the class response, but experience has shown that with a little prompting from staff pupils will start to appreciate that it is sometimes very productive to be slightly ‘wacky’ when generating such brainstorm. Staff may use some video of news footage of airdrops and disaster relief in action in order to underline the real need.

The next logical point would be for pairs to explore various issues in order to develop a fully practical device or devices which could lower a variety of payloads at a safe speed and be productively re-cycled after use. For example we could say that rice can be packaged in standard 1 kg packs. How fast can they fall before they burst on impact? Can we scale up a helicopter to provide a drop rate just slow enough to prevent the bag from bursting? How big would it need to be? Can we improve its aerodynamic efficiency so that as little material is used as possible?

In parallel other pairs could explore re-cycling the devices to tesselate back into forms which could provide shelter or water carrying/storage devices or boats. How would they join together? Can we treat paper to make it water-proof? Could we design a set of instructions which can be printed on the devices which would show how to use them for these purposes, but pictographically, so recipients anywhere in the world could use them?

As taught to student teachers this session only lasts 90 minutes. Students are then expected to use the principles in their own teaching experiences. At a simple level they can run a one-lesson ‘closed’ session where pupils explore the paper ‘helicopter’ and/or brainstorm out the disaster relief context. Teaching objectives may include the development of thinking skills such as brainstorming. The practical work is simple and requires no specialist facilities. At a deeper level computers could be used as indicated above for a variety of tasks simulating CAD/CAM whilst also running spreadsheets to simulate costs for materials, production, storage etc. The exercise could lead into a longer series of lessons in which teams could explore issues and produce competing solutions.

Conclusion
Good teaching uses a variety of approaches in order to maintain motivation. The approach outlined above is simply one approach that could be adapted in a number of ways and with different core ‘recipes’, at various age and ability levels. Key points are

• engineer-in positive feedback quickly; this can build a ‘can do’ attitude to design
• solving problems is fine, but much professional design starts by making something work better
• simple ‘recipes’, quickly made, and which ‘work’ are good starting points for design activity
• children need to be taught to ask and use ‘what happens if?’ questions
• children need to be shown the potential value of group brainstorming activity
• design and technology work should not be divorced from the world in which we all live; it should be seen as a key to improving that world

References