The 'Chair': Simulating Team-based Industrial Design

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Abstract

The paper explores the teaching/learning potential of a specific design simulation exercise based on the design of a chair modelled to 1:10 scale in card. This exercise can be adapted and used with age ranges from mid Key Stage 3 to undergraduate.

The reader is shown how such an exercise might be structured in relation to a teacher's specific objectives. Aspects of planning are explained followed by points on the running and de-briefing of such exercises.

The paper then explores the teaching and learning opportunities within the general approach. Aspects discussed are:

- the advantages and limits of simulation as a learning technique
- how the exercise may be used to focus class discussion on different design strategies
- design in a commercial context
- team based design
- the balance of mechanical, ergonomic, material and aesthetic considerations and the potential for integrating mathematical models and the potential uses of ICT.

This is to acknowledge the work of Walker and Cross (1983) who published the basic chair exercise in the Open University text *Design Processes and Products* and Mr J Flood who added the commercial simulation aspect.

Introduction

This paper aims to explore the teaching and learning potential of a design simulation exercise. This particular exercise puts participants into small teams each of which must design and construct a conference type chair to 1:10 scale. In full scale the chair would be made of 6mm plywood but the model is constructed using thin card. There are four phases:

- The scenario is that each team must design and make a chair in time for a large exhibition of furniture for conference venues. The chair is costed using a simple formula (see appendix).
- Teams then act as buyers for a conference centre needing chairs. They decide on criteria to select the chair they would purchase (not the one they designed) and place orders. The teams are, therefore, competing against each other.
- The design teams re-form and calculate the number of their chairs sold and profit made.
- The exercise is de-briefed. Staff can relate the experience to many points such as: designing in a team, structural design, aesthetics, design for production etc.

The exercise is flexible, the time scale being, typically, about 90 to 120 minutes. In a school the phases could be split to suit timetables: phase one requires about 60 minutes. Staff can easily alter the exercise to suit their specific teaching objectives and pupil age and ability ranges.

A typical structure

Planning/preparation

This exercise can be run with what would normally be considered large teaching groups. A group of 20, in teams of four or five is small but adequate; a group of 50 in ten to twelve teams offers more potential for learning due to the wider range of solutions and opinions in de-brief.

Each team requires a table and chairs. A small table which four or five people can sit around means easier communications. A work bench would suffice if necessary. Tables should be arranged so that staff can easily move between them, observing teams and individuals.

Each team requires:

- a briefing sheet (appendix, adapt for age/ability range)
- A4 paper for sketching and rough 3D modelling (use waste paper with one side clean)
- one clean sheet of thin white A4 card per team for the final modelling
- pencils, rules, one or two pairs of scissors and adhesive for paper/card
- felt tip colour pens should be available if teams decide to apply colour.

Teams sizes can vary from three to five. More than five and there is not enough work to go round, less than three and the team interaction is too limited. Teams may be allowed to self select or staff may select on various criteria. Examples may be: random, based on class lists; or engineered on the basis of mixing gender, cultural background, abilities etc. Self selected teams tend to have similar attitudes and, therefore, a more limited range of perspectives. Mixed teams are better but can be more fractious.

Design and make (phase one)

Participants need to be quickly sorted into teams on the criteria decided. The briefing sheet is issued and used to introduce the topic. The deadline for completion of the model and the fixing of its selling price should be set, normally 75 minutes after the start point. After

a period of about 30 minutes it is often a good idea to increase the pressure on teams (optional) by announcing that "due to a booking problem at the exhibition centre" the deadline has been moved forward and is now 50 minutes from the start, i.e. in 20 minutes time. Staff can then observe the way teams manage the extra stress and raise it at de-briefing.

As the exercise progresses staff should circulate, observe, and note points they wish to raise at de-brief. For example: how different teams tackle their design process, how they manage decision making, how they support each other, whether all are contributing, how different individuals may contribute in different ways. Staff should also note how the teams model their ideas and develop them.

As the deadline is reached all chairs must be finished and placed on a piece of A4 paper with a product name and selling price shown (not the cost price). Prior to this the selling price would have been arrived at by using the costing information on the briefing sheet. Firstly a cost price is calculated and then a profit margin decided by the team and added. This a much simplified model of costing and, at de-brief, more sophistication can be discussed by considering factors such as salaries, profit margins and overheads. If working with more experienced pupils staff may make the formula more complex by including some of these factors. The formula could be entered on a database.

Decide purchasing criteria and place orders (phase 2)
Staff re-brief teams: they are now buyers for a large conference centre who have come to the exhibition with a specific budget to spend (nominally £1000). They must decide their own criteria to evaluate the various chairs and spend their money appropriately. They would not, necessarily, buy the lowest cost chair, but one which suited their purposes and taste best. Once they have decided they place an order by stating on a piece of paper their team number, how many chairs they are buying and at what cost. This order is placed in an envelope by the chair they are buying. This phase will require about 15–20 minutes.

Calculate sales and 'profit' (phase 3)
The design teams then re-form and see what orders they have won and work out their total sales and profit. They then enter this information on a central overhead projector sheet, poster or computer spreadsheet.

De-brief (phase 4)
The de-brief can be directed by staff questions, encouraging pupil discussion, but focusing staff objectives for the simulation. Teams might be asked:

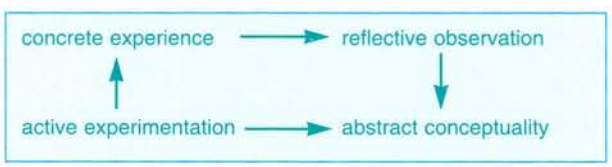
- how they went about designing – clarification of task, idea generation, decision making, modelling etc.
- how they managed their time
- how they delegated tasks
- if and how they used the costing formula during the design phase to fine-tune their design and lower cost
- how they felt about working under pressure
- the relative importance they placed on structural as opposed to aesthetic design
- did they consider static and dynamic loading, mis-use, recycling materials etc.
- how they approached the ergonomics of the chair
- whether the simulation is accurate to life, if not, in what way?
- whether they enjoyed the activity.

Analysis of teaching/learning opportunities

This exercise, and others like it, could be used to deliver those aspects of the National Curriculum which require pupils to experience working in teams and aspects of industrial production. Similarly it calls on mathematical, technological and aesthetic capabilities plus many 'key skills'.

In any teaching and learning situation an important principle is to move from a pupil's concrete experience towards the abstract. The use of a simulation exercise such as 'the chair' means all pupils can quickly be given a common ('concrete') experience on which to base discussion. This discussion immediately follows the exercise and so can be more effective and allow the learning to be projected into the 'abstract'.

Simulations are imitations of reality, with limits and limitations. They are used to simplify complex situations and so possibly improve learning. Complexity may be increased incrementally and focus changed and/or broadened in order to develop the learner. Hence we have a learning cycle:



Simulations are not as effective as more conventional teaching for mastering facts (Percival 1978, Jones 1990). However, Adams (1977) considered simulation techniques more effective for modifying attitudes and developing confidence. Pupils easily see the

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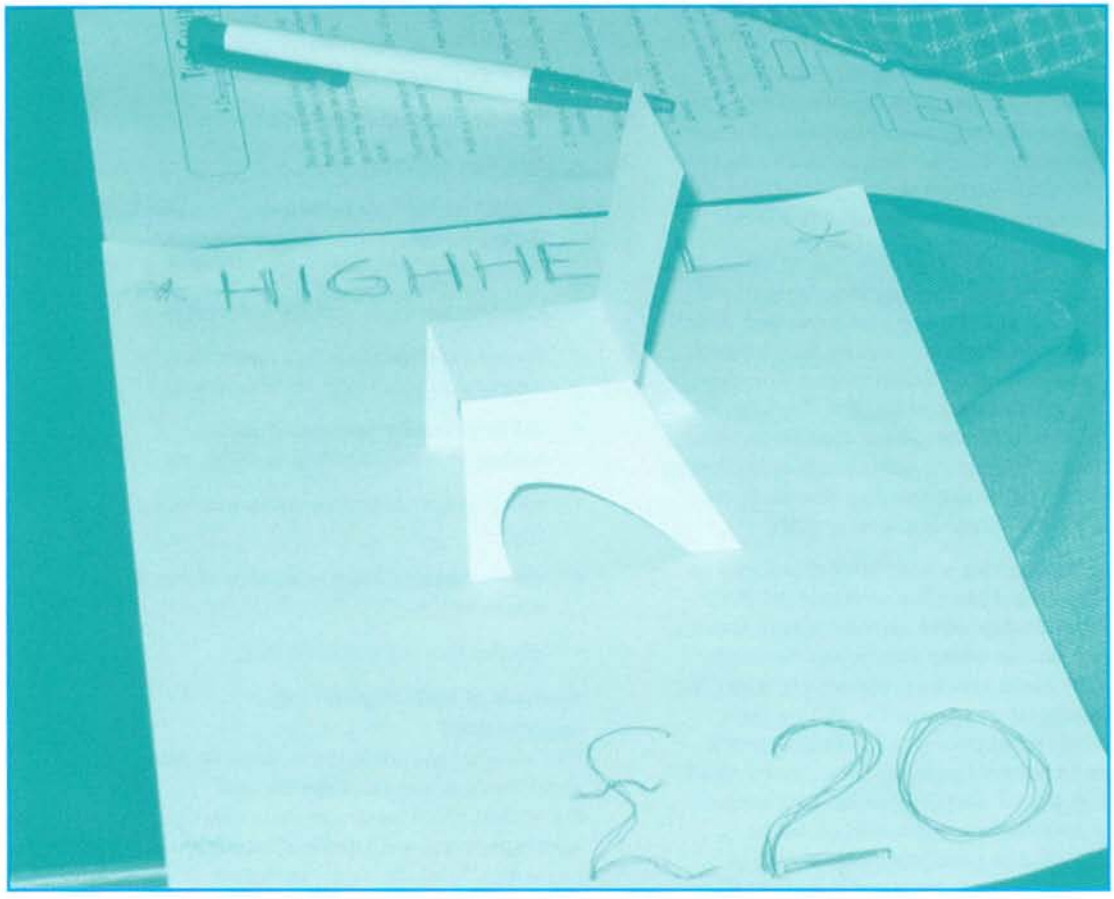
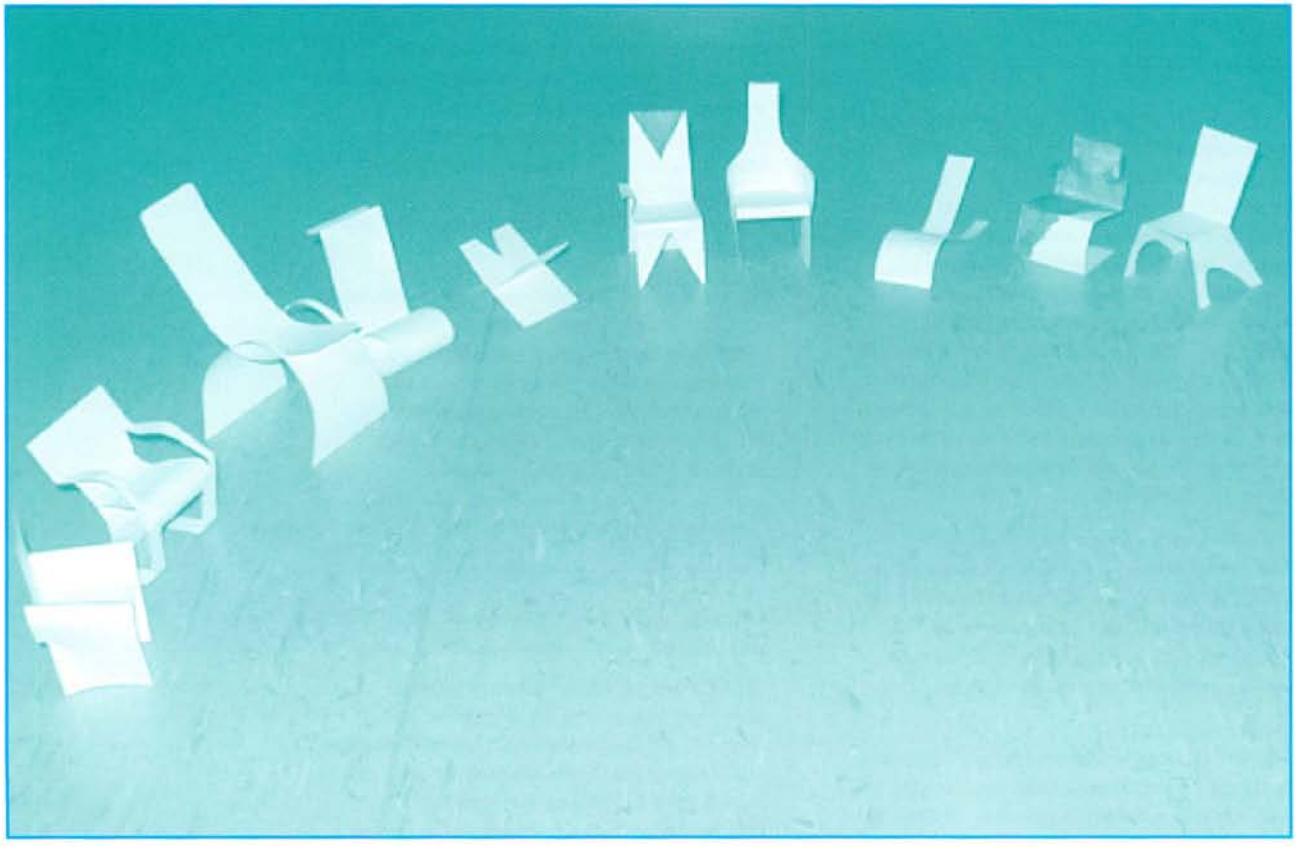
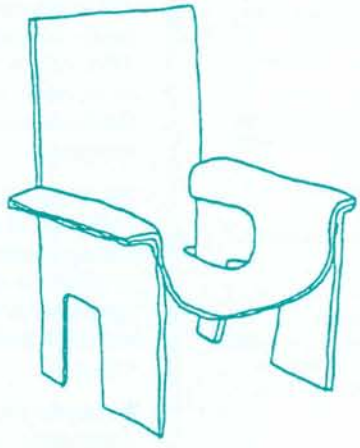


Figure1
Figure 2 and Figure 3 opposite



THE CHAIR
A Design and Marketing Simulation

This chair was made from a sheet of plywood that was cut, folded, rolled and glued to achieve the form you can see on the right. It was made up from the 'net' you can see below (not to scale).



Your task is to design and make a chair of your own using the same techniques.

Work to a 1:10 scale (100mm=1 metre full size)

1 Working in your teams, make up your design in card, by the deadline given.

2 Work out the cost per chair using the information below, remember to include waste.

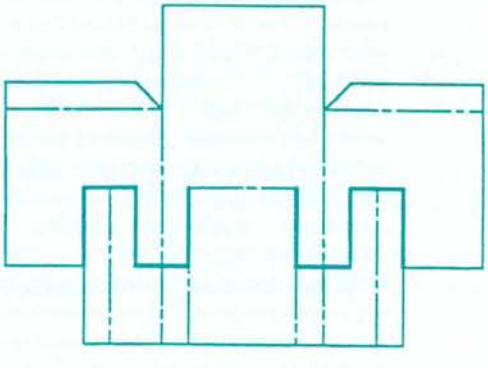
3 Set your selling price, that is cost per chair + the profit you wish to make per chair.

4 You will be briefed on the market simulation. You have £1000 per team to spend.

5 After the market place work out how many chairs you sold. If you multiply this by the profit per chair you will have a total income.

number sold x profit per chair = income

[ ] £[ ] £[ ]



Manufacturing costs:

material	£1 per square metre (full size)
cutting	10p per length of cut
folding	10p per fold up to 90°
rolling	10p per roll up to 90°
glueing	10p per join
finish	50p per colour applied

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References

Adams, R.J. (1977) *The Development of a Simulation Game for Library User Education.* MLS thesis, Loughborough.

Jones, K. (1990) *Terminology. Simulation/Games for Learning.* 20, 4, December, 355-359.

Percival, F. (1978) Evaluation Procedures for Simulation/Gaming Exercises. In *Perspectives on Academic Gaming/Simulation* 3. 163-169.

Walker, D., Cross, N. (1983) *Design Processes and Products* The Open University T263 Unit 1 pp11-16.

relevance of this type of simulation to their futures in relation to team working, communications and understanding a commercial context for design. This, and the short time scales of the exercise, appear to assist motivation.

There is evidence that simulation, when used effectively, can boost motivation in 'less able' pupils to a greater degree than others (Percival 1978, Adams 1977). Simulation events tend to be enjoyable for participants (the author's fieldwork) which may be one factor in boosting motivation.

The author has used this simulation with Year 9 pupils and all age ranges above including undergraduates. The technique is very flexible in relation to age and ability. As staff gain experience in the use of such simulations they can add features of their own and experiment with tasks.

During the simulation the teacher's role is to establish the 'environment' of the simulation, to monitor the simulation in action, to de-brief. Teams become very focused and staff will find they have time to observe uninterrupted. This is a valuable opportunity for observation and selective intervention.

De-briefing should be based on points raised by teams, but staff can steer an agenda of their own. They may focus on working in teams: the pro's and con's of team based design, working in a mixed team or with friends, values, working under pressure. Similarly staff could relate the de-brief to design and production in industry.

As pupils work together staff will observe different design strategies. Some teams start by working independently to generate ideas and then pooling them to decide which to adopt for development. Others immediately enter discussion on specifications and how to approach the task. As the task progresses staff will observe aspects such as methods of team design decision making, delegation of tasks, use of the financial model. These can be raised at de-brief and compared in discussion.

It is interesting to note the balance between technical and aesthetic considerations. Within the technical we have various structural aspects such as forces in static loading, dynamic loading, loading in 'mis-use' situations. This can lead to questions of product liability law at de-brief. Within the aesthetic we have form, colour and detail. Compromises can be observed and discussed.

Ergonomic data is needed. Do teams realise this? How do they gain it? Typically they will measure existing chairs; they may consult ergonomic data on posters etc., depending on what materials staff wish to make available.

Mathematics can be applied in the financial model in relation to scale, working out the area of material used and in the costing formula. With younger pupils squared paper can assist area calculations. The tessellation of chair nets to gain maximum use of the A4 card is an interesting area for discussion in relation to effective use of materials and minimising costs.

Simple adhesives are used to join the model. In de-brief this can lead to discussion of various fastening options and their pro's and con's.

The exercise offers opportunities for use of ICT, particularly if more time is available. The design work can be done on a simple drawing package and then printed onto the thin card which will go through most printers. Pupils can use the package to tessellate the design to gain maximum use of the card. One step up is to use a cutter/plotter directly on the card (CAD/CAM). More specialist design packages can be used for design work. Computers can be used to support the exercise by carrying ergonomic and structural data together with the financial model. All can be entered by staff onto simple spreadsheet type packages. These can then be used during the design phase to explore the structural and financial implications for design decisions. The computer can then be used to compare the financial performance of each chair. Other factors can be entered in a spreadsheet such as teams deciding their salary and working overheads such as larger or smaller premises, heating, lighting, hire or purchase of machines, advertising etc.

Conclusions

This simulation has been proven over time and with a wide range of ages and abilities. It offers staff a way of introducing pupils to many key aspects of National Curriculum requirements for design and technology and key skills. As an exercise pupils readily recognise the relevance of the work and the short time span allows them to maintain this focus leading to high levels of motivation. The exercise acts as a useful and 'concrete' experience that, once gained, can be referred to and built on in many other aspects of design and technology work. It offers a holistic design experience which also enables staff to link ICT, maths, aesthetics, technology, commerce, industrial production and working in teams. Above all pupils find it fun. Staff can gain experience of running such simulations at a simple level and then iteratively develop them. The topic could easily be changed to the design of packaging or textile type products. The simulation could be run as a 'warm-up' for more extended design work which might include work with food, textiles or the resistant materials all of which could be individual or team based.