Emergency shelter design

Emergency shelters for disaster relief are an ever present necessity.

At the time of writing this article – June 2009 – they are used for refugees in the Swat valley in North West Pakistan. Some examples from earlier disasters are shown here.

Closer to home

Anyone who has ever camped in a tent will understand that finding the perfect design, that will be simple and quick to erect, be stable in a variety of weather conditions, and will accommodate a number of people sleeping, sitting or even standing is not straightforward and compromises need to be made. For example, having sufficient height for several people to be able to stand can mean that the tent will use more materials, be less stable, and more difficult to erect. In disaster situations, time and resources are at a premium, so designs need to be simple, cheap and quick to erect.

Catalogues for leisure tents show plans with sleeping layouts and elevations with measurements but the information is frequently incomplete. Interpreting this information and using it to check that a tent will meet your requirements requires ‘functional mathematics’.

Covering the GCSE syllabus and ‘Functional mathematics’

All teachers of examination classes feel under pressure to cover the syllabus, but nowhere is this pressure felt more keenly than in Further Education colleges which have a large cohort of students from a wide variety of institutions and backgrounds arriving each September with just eight months to cover the GCSE syllabus. The need for a common timetable format to suit the wide variety of classes and subjects within a college may mean that timetable arrangements are not always ideal.

One college in particular which takes students from a wide range of ethnic backgrounds from across the entire London area has been piloting GCSE Use of Mathematics which includes Functional Mathematics. Learners at the college, from age sixteen to adults, take GCSE mathematics courses because they need to achieve a certain grade for vocational, academic, or professional progression. Often they have attempted GCSE mathematics previously with limited success. Consequently, they approach mathematics with negative attitudes and a fear of further failure.
What are they trying to achieve?

The college wants to increase learners’ interest and motivation in mathematics, to enable them to be functional in mathematics when they leave the college, as well as helping students to achieve success at GCSE. Project work has previously been very successful for ‘key skills’, but coursework is no longer part of the assessment and time for extended project work is limited by the college timetable. The mathematics department would still consider doing more extended rich activities if ones could be found that:

- engage their learners, and are relevant to them
- are set in a real world context
- provide opportunities to cover a range of mathematical content through a single task/context
- provide opportunities to develop functional skills, including those needed for interpreting pre-release datasheets, which are part of the functional skills assessment.

How could they organise learning?

A consultant met with staff to look at possible activities and strategies for their GCSE students, in particular, relating to the functional mathematics element. A number of strategies and activities were considered including using datasheets as a means of encouraging students to ask their own questions.

Design an emergency shelter for use after a natural disaster such as an earthquake or a tsunami was established as a possible extended task for several reasons.

- The global dimension would appeal to the multi-cultural mix of the college students, and provide an interesting introduction and context for the project.
- The task would require the use of a range of GCSE mathematics content such as:
  - Handling data – finding and analysing body measurement data to plan the dimensions of the shelter for specific purposes – sleeping, sitting, working, …
  - Geometry and measures, 3-D shapes, 2-D representations, nets and construction, angles, scale drawing and measurement, finding lengths and areas to determine the materials required for example, quantities of fabric needed, lengths of poles etc.
  - Number – costing the materials required.
- The task can be tackled in a practical way using constructions and scaled measurements together with using calculations – this ensures accessibility and suitability for a range of learners. The task is well suited to group work and collaboration.

- A datasheet could be used with costing information about materials to construct shelters.
- If students have access to a free 3-D dynamic geometry software plug-in, this would enable them to manipulate pre-prepared shelter designs to help them with visualisation and determining internal measurements.

An initial package of materials was prepared including:

- PowerPoint presentations showing a range of shelters or tents being used in disaster and other situations.
- suggestions for starting the task with possible questions, approaches and content.
- suggestions for lesson objectives.
- a datasheet with prices and measurements of fabric, poles and other materials that might be needed.
- examples of simple tent designs in 3-D dynamic geometry software, with cross sections that could be manipulated to aid visualisation and help find measurements.

The lesson materials included examples of questions such as:

- How much height is needed for sleeping – lying flat, or on your side? Can you make use of the whole of the floor?
- What is a reasonable height at the centre? Although you are mainly using it for sleeping you will need to be able to get in and out, probably on your knees, and you may want to sit up to get dressed! What should be the angle of the walls to achieve the height needed over enough of the tent?
- Do you want a tent to fit the average person? Tough on tall people! What percentage of people would you like the tent to fit?
- What scale will you use for your diagrams and plan?
- What questions might need to be answered if the tent was being used for a different purpose?

How well are they achieving their aims?

Initial trials

Some of the materials were tried by one teacher in a two hour lesson. The students really enjoyed the task thinking it was interesting, important, and relevant. They were actively engaged in productive discussions about how to measure, which measure-
ments to take, and which scales to use. Each stage however took much longer than the teacher had anticipated, and he became concerned that teaching and learning in this way would take more time than was available in the timetable.

If the task did cover all the potential syllabus topics then it would be reasonable to spend considerable time on it, but given time limitations in the college teachers felt it was too risky, and that strategies needed to be found to access the key parts of the task more quickly.

This highlights the dilemma that teachers face when they feel under pressure of time, the tension between trying out new ideas, and losing valuable time. It was not possible to access ICT facilities for the trial lesson so the software plug-in wasn’t used.

**Developing the task**

Further discussions took place about how to enable the students to access the task more quickly. The introduction needed to be streamlined, or simplified in order to make best use of the limited time.

Several possibilities were discussed to increase accessibility:

- Use a simple ridge tent design page from a camping catalogue. The information about measurements, layout of the tent and the number of people it could sleep would make it look like a datasheet which students could interpret. Students could be asked to evaluate the design using body measurement data. Would it be comfortable to sleep in, sit in or dress in? Could they design a better tent for two people?
- Construct models using straws and pipe cleaners, as it would be quicker and would support visualisation.
- Give students the opportunity to try a real tent.
- If the software plug-in was available, on at least one computer, then it could be used for demonstration. Groups of students could then access it for short periods to manipulate the designs and define measurements which they could use to inform their own designs.

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### Whole curriculum dimensions

- cultural diversity
- global dimension and sustainable development
- technology and the media
- creativity and critical thinking

### Curriculum opportunities for mathematics

- linking areas of mathematics
- modelling with mathematics
- opportunities for collaborative work
- opportunities to work with a range of resources and technology

### Key Processes and Functional Mathematics

**Representing**

- recognising the potential to use mathematics
- choosing suitable mathematical models for their designs
- representing designs mathematically in different forms (e.g. 2 and 3 dimensions)
- selecting the information data, methods and media to use

**Analysing**

- using appropriate mathematical procedures
- changing values to see the effect on their models
- finding results
- estimate, approximate and check working

**Interpreting and evaluating**

- comparing and evaluating the effectiveness of different designs
- considering the appropriateness and accuracy of their results

**Communicating and reflecting**

- choosing appropriate forms to present results
- discussing and comparing solutions

### Number and algebra

- calculations with rational numbers; proportional change; use of formulae

### Geometry and measures

- properties and mensuration of 2-D and 3-D shapes; 2-D representations of 3-D objects, nets; metric measures and conversion between them; possible use Pythagoras' theorem and trigonometry

### Handling data

- The handling data cycle. Measures of central tendency and spread. Possible use of cumulative frequency tables and graphs.
Additional 3-D dynamic geometry software designs could be created to match the camping catalogue design.

**Work in progress**

This is an ambitious project, and there has not been an opportunity so far to trial the task further, but there are plans to try it with two teachers using a team-teaching approach. The task has the potential to meet many of the requirements of the revised secondary curriculum.

**Extending the shelter design activity**

The tent design in the previous example was chosen because it could be modelled by a simple triangular prism and the related activity had the potential to cover much of the GCSE mathematics content that students need. For these particular classes there was a need to keep some aspects of the problem simple, for example the basic tent shape. The 3-D dynamic geometry models were created for students so that they could manipulate them to speed up the process. Where time is not so crucial, some students could progress to using the software to create their own designs.

In different circumstances a similar starting point for an activity, designing an emergency shelter, could present opportunities not only for mathematical modelling, but for creativity and critical thinking. Students could look for innovative shelter designs and ways to model these with mathematical shapes. They might use 3-D dynamic geometry software, or practical means of construction, to help them find the internal measurements. Geodesic domes are one possible example.

**Geodesic domes**

Some companies make geodesic relief tents such as the one shown here. These come in kit form.

www.shelter-systems.com/relieftents/

One school used instructions from the internet to make geodesic domes from rolls of newspaper. Several versions of instructions, which can be printed out, can be found by searching for ‘Geodesic domes from rolls of newspaper’. Instructions generally involve making 65 tubes in two different lengths 35 of one length, and 30 of another. Students worked in groups electing a captain and designating roles within the group.

They first made scale models using straws – each group choosing its own scale.

The two groups whose models are shown chose scales one of which was double the other. This created some discussion about similar shapes and their relative volumes.

The base decagon was drawn on paper and used to fix the first layer. Students went on to construct the full size model.

The next challenge was to calculate the height, which could be verified by measuring.

The next question was ‘What angles and lengths can you find?’

The students did find this difficult, but the models helped them to visualise where right angled triangles exist so that they could use Pythagoras’ theorem and trigonometry.

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