



Science For All Case Study

A tool to support graph drawing in secondary school

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Background

This tool was developed in a secondary school with a comprehensive intake and an average number of SEN pupils. The school has a large integrated resource unit for pupils with Asperger's syndrome and those with Autistic Spectrum Disorder (ASD), thus attracting a disproportionate number of pupils to the school with these conditions who are not officially supported by the Integrated Resource.

The issue

Experience has taught us that pupils come to us from primary school with a well developed skill (that borders on habit) of drawing bar charts or histograms. They are far less familiar with the idea of a scatter graph or line graph (which for simplicity's sake will be referred to as 'line graphs') and SEN pupils in particular can take a long time to acquire the skills needed to plot these kind of graphs successfully.

We saw the skill set broadly as follows:

1. Understanding why a graph can be a powerful visual tool for the display of data
2. The ability to select a suitable scale for axes and to label their intervals in equal steps
3. To understand what physical quantities were represented by each axis and therefore draw a meaningful conclusion from the data
- 4. To plot data points accurately with the simple idea of Cartesian 'across and up'**
- 5. To select a suitable line of best fit for the data**

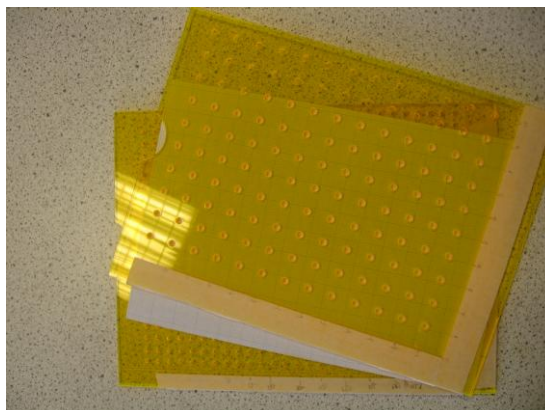
Through discussion between SEN support staff, integrated resource staff and science teachers we decided that one-to-one work supporting SEN and ASD pupils would be best focussed on the practical skills 4 and 5 highlighted in the list above.

Very early on in our discussions we agreed that a tactile tool was required that could remove some of the fear of failure experienced by pupils as they struggle to acquire a complex skill set.

The Resource

Having rejected the idea of working with acetate sheets, we decided to develop a tool that was essentially a transparent Perspex sheet with holes in it arranged on a simplified grid, into which pegs could be inserted for data points.

We wanted to allow pupils the chance to use pegs and therefore change their mind about where data points should be plotted, but to support them by simplifying the huge number of lines on secondary school graph paper to the essential points on a grid. This support would be by limiting their choices to the pre-drilled holes in the Perspex. They would then be able to stretch an elastic band between pegs to select a line of best fit (either straight or curved).

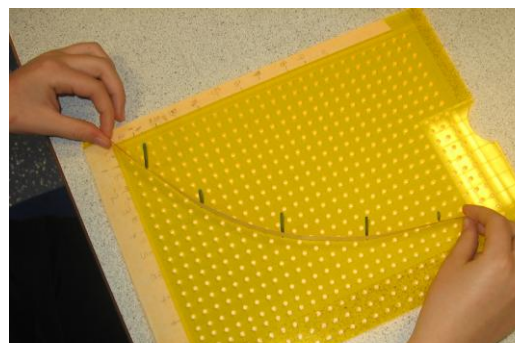


Working with the technician from the DT department we first tried out two clear Perspex sheets attached together with a very thin gap between them in which could be inserted a sheet of graph paper. The initial idea was that we could differentiate the tool by having the holes on one side much closer together than on the other (1cm separation and 2cm). However, we found it very difficult to get the graph paper grid to line up with the holes once slotted in, as each sheet of graph paper is cut with a slightly different margin. We tried using downloadable graph paper, which solved this problem and had the advantage of being able to customise the graph paper to simplify it. For example we could print 2cm graph paper to match the holes in the Perspex sheet that we were using.

There are several websites that provide free, downloadable graph paper. For example:
<http://incompetech.com/graphpaper/square.html>
or
<http://www.mathsphere.co.uk/resources/MathSphereFreeGraphPaper.htm>

We rejected downloadable graph paper as the advantages it brought were outweighed by the extra complications, although the idea is still sound.

We also rejected the idea of having two sheets stuck together, as it was essentially only a cosmetic attraction of the tool. Once pupils had decided on their data points and removed the pegs, they found their pencil points going right through the paper as the holes were aligned with each other! Simply securing a piece of graph paper to a desk with Selotape and carefully laying the Perspex sheet on top was much simpler and more effective.



We also dropped the idea of using an elastic band to illustrate the idea that a line of best fit did not join all the data points dot-to-dot. Much to the pupils' frustration, the bands would simply pull out the pegs that we had been using and even when we switched to using match sticks we felt that the bands still weren't adequate unless the line of best fit happened to be able to attach near the beginning and end to convenient points. The switch from game board pegs to match sticks bought the added advantage however of giving the grid holes a more suitable diameter for the 1cm sheet.

Having rejected the elastic bands we toyed with the idea of flexible alternatives such as wire (rather too sharp and difficult to curve) or a draughtsman's' curve drawing tool from an art supplier, but in the end we used strips of cardboard to produce lines of best fit. Laid on their edge they created a smooth and flexible line. The pupils could then make a decision about where to place the line before committing to drawing the pencil line either on the Perspex using pegs to guide them or on the paper with the pencil points. Once pupils had been able to discuss potential shapes for lines of best fit (straight lines or curves) they could go ahead and replace the matches with pencil marks, remove the Perspex sheet and add a line of best fit with confidence.

Implementation

After several trials with SEN and ASD pupils we used their feedback to make final modifications to the tool, and the way in which we use it effectively.

- It was helpful to have the axes clearly marked on the Perspex sheet with notches for the major divisions. This could be removed to differentiate for more able pupils who were working on skill 2 from the list above, but for the pupils we were working with it provided a useful visual cue that they were plotting a graph using Cartesian axes. A board pen or erasable marker could then be used to label the divisions, and be wiped clean for each different data set.
- It was helpful to be able to differentiate the use of the tool when working with a small group of pupils with a spread of abilities. Differentiation can be built in through:
 - Using a simplified grid with holes spaced at 2cm intervals and a very simple data set (for pupils unfamiliar with the idea of graphs).
 - Use of a more complex data set that still show proportionality but have degrees of scatter around a straight line of best fit.
 - The introduction of outliers to the data set that can lead to a discussion about how anomalous results should be treated.
 - Use of data that generates a curve of best fit rather than a straight line.
 - Making minor adjustments to data/plotted points and seeing the effect on the line of best fit and therefore the overall conclusion.
- We had to be very careful to ensure that the data sets used could be plotted on the grid provided. This limitation of the grid also meant that care was needed when using it as a tool to support the work of TAs in class with pupils who were working with real data from an experiment. It was more effective as a stand alone tool to develop the skills in pupils so that they could apply them in an appropriate situation.
- We found that coloured transparent Perspex was more useful than colourless to many pupils, especially those with visual impairments or who were colour blind.

Practical details:

Suppliers:

Perspex: Direct Plastics, Unit 7, Portland Business Park, Richmond Park Road, Sheffield, S13 8HS. Contact Gary Dawson Tel. 0114 256 0889.

Match sticks: YPO coloured match splints pk 2000 @£2.75 order no 550973 www.ypo.co.uk

The grid was cut from Perspex sheets measuring 760mm by 1000mm. It is 6mm light gathering acrylic sheet and comes in 5 or 6 different colours. Any laser cutter should do it even the smaller less powerful ones. Ours reads programs created in CorelDraw or 2D design.

If your school doesn't have access to the materials or equipment needed to make the tool then we'd be happy to make a few for school use at a price that would cover the cost of materials and postage. Contact :

Matthew Bailey mba@ecgbert.sheffield.sch.uk
or Mike Lowe (DT technician) ml@ecgbert.sheffield.sch.uk.

Summary

Pupils who lack the skill and confidence to plot data points for a line graph can be supported by the use of a tool that limits their options and guides their decisions. The familiar graph paper is still visible beneath a transparent Perspex grid in which pupils place match sticks in holes to practise plotting data before finalising their decisions and replacing the match sticks with pencil marks.

We found that this was a supportive tool that could be used flexibly with a range of abilities and could be easily differentiated to support different needs.

As a tool for teachers, TAs or other staff we use this tool as an effective means of working with pupils to acquire difficult skills.