

4. Wrists and Necks - Designing a long sleeved shirt/blouse

How do manufacturers decide on the sizes of collars and cuffs? What advice can we give?

Background

This starting point has been used with GCSE mathematics and statistics classes as a means of introducing them to a range of statistical measures and forms of representation such as box and whisker plots, histograms, scatter graphs etc. It is also a useful way of showing pupils how ICT can be used to support their statistical surveys in increasing the speed and efficiency of processing their data. In the study that follows, the teacher used the TI83 graphic calculator because of its range of statistics features and the fact that it could be used in the normal mathematics classroom. She also used the opportunity to cover the topics of ratio and proportion, place value degrees of accuracy and rounding to two decimal places. The pupils were reasonably familiar with the graphics calculators, having used them for every day calculations and for plotting graphs.

The Lesson(s)

Clothes play an increasingly important part in pupils' lives and I thought this task would make an interesting starting point for the mathematics, in particular data handling skills, that I wanted to teach. I asked them if they were aware of the kind of decisions that clothes manufactures have to make when designing and making say shirts and blouses. How do manufacturers decide on the size of collars and cuffs? A number of pupils suggested that this would depend on the design of the shirt or blouse, whether it was loose or tight fitting. I agreed but asked them whether they thought there was a connection between wrist and neck measurements. Several said that they thought that there might be, and offered that the neck was probably about 3 times the wrist. I then said we would collect some measurements from them and that I would show them how to use the statistics functions on the calculator to find answers to this, as well as look at the different ways we could display the data. Later they could use the graphic calculator to explore questions of their own.

I didn't have sufficient numbers of tape measures, so I handed out strips of A3 paper for them to take measurements. I said it would be interesting to see if there is a gender difference and said it would be useful to enter these separately. I entered their results directly into the 'teachers' graphic calculator using the viewscreen and OHP for the whole class to see. I inserted four headings **FW**, **FN**, **MW**, **MN** (female wrist size, female neck size etc.).

FW	FN	MW	1
15	32	16	
17	35	20	
20	41	19	
15.5	35	19	
17.5	36	17	
16	33	18	
15	35	17	
FW = {15, 17, 20, 15...			

FN	MW	MN	4
32	16	36	
35	20	39	
41	19	42	
35	19	41	
36	17	38	
33	18	38	
35	17	39	
MN = {36, 39, 42, 41...			

The full set of results is as follows:

FW	15	17	20	15.5	17.5	16	15	15	15	17	17	16	15.5	16
FN	32	35	41	35	36	33	35	34	34	37	35	35	36	34
MW	16	20	19	19	17	18	17	15.8	17.6	16.5	17.8	19.5	17.5	
MN	36	39	42	41	38	38	39	38	40.1	37	37	40	36	

Some of the pupils wanted to enter the data into their calculators while others wrote them down in their exercise books. At this stage I did not want them to be distracted by questions about "which keys to press".

I then asked them how we could check out their conjecture that the neck was 3 times the wrist. Some suggested that we just divided **FN** by **FW** and **MN** by **MW** and compare several answers, others suggested finding the average size neck and wrist. I asked them to do this in any way they chose. Most pupils used the graphic calculators in the normal home screen mode. I showed them how we could calculate the ratio, male wrist: male neck, very quickly using the list commands (much like a spreadsheet).

MW	MN	$\frac{MN}{MW}$	# 5
16	36	2.25	
20	39	1.95	
19	42	2.2105	
19	41	2.1579	
17	38	2.2353	
18	38	2.1111	
17	39	2.2941	
L1 = " LMN / LMW "			

I then showed them how we could calculate the average ratio for boys in two ways:

```
sum(L2)/13
2.178609011
```

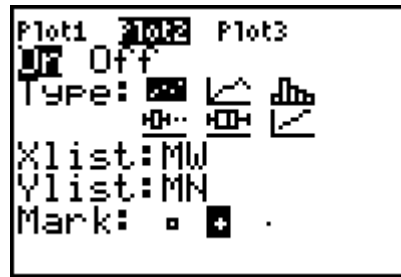
```
EDIT MATH TESTS
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7:QuartReg
```

```
1-Var Stats
x=2.178609011
Σx=28.32191715
Σx²=61.8885735
Sx=.1245624309
σx=.1196757126
↓n=13
```

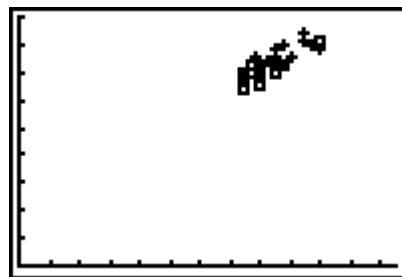
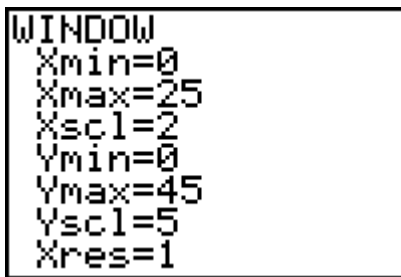
I said they could choose which ever they found easiest. We discussed the "funny" symbols on the third screen above, including standard deviation, and I said that this was a way of measuring the variation. We also discussed what would be a suitable degree of accuracy.

I then asked the pupils to look at the female data and compare those with the boys. I encourage pupils to help each other and most worked in pairs or three's. This makes it a lot easier when working on new skills with computers or graphic calculators. As a memory aid I also have a large display of the calculator pinned to the notice board at the front of the class with some of the key menus such as WINDOW, STAT and MATH highlighted.

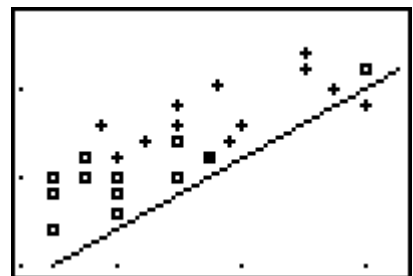
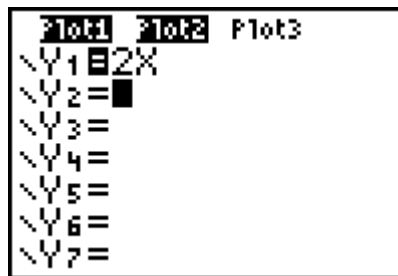
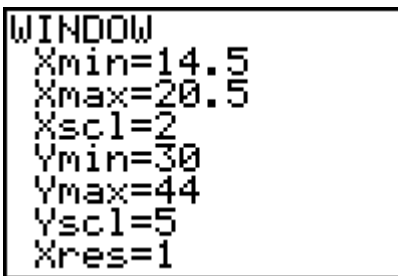
I asked them what else they could do to check the relationship and several suggested a scattergraph. I said they could plot the data (boys and girls) onto graph paper or use the calculator. They would need to think about scales and starting points on the axes. I showed them how to plot the points on the GC and for them to find a line of best fit. They could plot the data (boys and girls) separately and/or together.



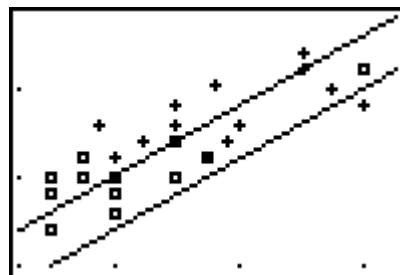
I asked them for suitable sets of values for the axes. Wrist is on the X axis and Neck the Y axis. We superimposed both sets of data, squares for females and crosses for males.



They were familiar with plotting functions so I asked them to select better values in the WINDOW and experiment with lines of best fit for both sets of data. One group produced the following for the combined data sets:



Later, pupils established that $Y = 2X + 3$ gives a better fit (by eye).



In the following lessons we discussed how we might try more "mathematical" ways of getting a line to fit, through, for example, finding the "average" wrist, neck point on the graph and looking at the lines that passed through this point. I also suggested that they could split the data in half (say, sorting on

wrists) and find two averages, or use the line that passed through the lower and upper quartiles (They noticed that they could get the quartiles, along with the mean, in the 1-Var Stats option)

I told them that the graphic calculator will work out a "best fit" and showed them how this was done for the female data.

```

EDIT [MODE] TESTS
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
    
```

```

LinReg(ax+b) LFW
, LFN
    
```

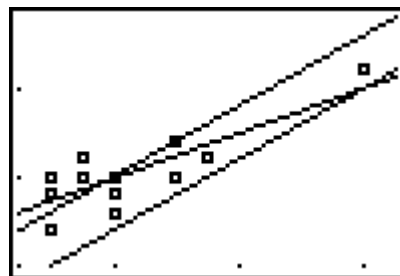
```

LinReg
y=ax+b
a=1.266331658
b=14.5649677
r²=.6911537887
r=.8313565954
    
```

I then asked them to round the "calculator equation" to a suitable degree of accuracy and compare this with their own. Some were curious to know how the calculator did this and I said that "basically it did this by minimising the distance between the line and the points". The plot below shows the female data.

```

[MODE] Plot2 Plot3
\Y1= X
\Y2= 2X+3
\Y3= 1.27X+14.6
\Y4=
\Y5=
\Y6=
\Y7=
    
```



Later on with the more able pupils I showed them how they could manipulate the lists to look at the difference between the actual (observed) data and that predicted by their model. We found the "average difference" in two ways; using $ABS(O-E)$ and $(O-E)^2$.

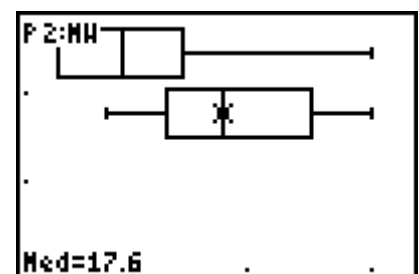
By the second and third lessons they were quite familiar with plotting scatter graphs manipulating the lists, including transferring data between calculators. I also showed them how to use the box and whisker plots and histogram options. The box and whisker plots are a really useful and accessible way of comparing data sets.

```

WINDOW
Xmin=14.5
Xmax=20.5
Xscl=2
Ymin=30
Ymax=44
Yscl=5
Xres=1
    
```

```

[2ND] [MODE] PLOTS
1:Plot1...On
  [MODE] FH 1
2:Plot2...On
  [MODE] MH 1
3:Plot3...Off
  [MODE] L1 L2
4↓PlotsOff
    
```



I highlighted different parts of the box and whisker and asked them to interpret the diagram for the female and male wrists measurements.

After showing them how to plot a histogram for the female neck sizes I asked them to experiment with the scales (group size) and to compare male and female results.

In the third lesson I asked them think of other data, and relationships that might be important to manufactures in the clothing industry. Some pupils continued this topic and presented it for their coursework. One pupil look found a reference to Leonardo da Vinci's "Vitruvian" man and the Golden section/ratio on the MS Encarta CD-Rom and explored relationships between different sections of the body.



This drawing from the notebooks of Leonardo da Vinci, known as "Vitruvian Man" after the architect Vitruvius, demonstrates the proportions of the Golden Section: the sections of the body from head to waist and from waist to feet are to each other what the section from waist to feet is to the length of the whole body. The fact that the "divine proportion" was to be found in the human body was seen as highly significant in the Renaissance, the age of humanism.

Scala/Art Resource/Art Resource¹