

Never Trust a Calculator

I was teaching some extra curricula Maths to IB students the other day in preparation for their investigation. As an example I asked them to consider a questionnaire to fellow students on what they thought of animal research. Draw up a seven point scale and ask boys and girls to mark their attitude on that scale.

I asked my wife if she thought there would be any difference in the results. She said she might suspect that girls would be more opposed to animal experimentation than boys. So I just made up 10 results for boys and 15 results for girls and wrote a short explanation sheet showing students how to undertake the various calculations to see if the difference in the results were statistically significant.

I rigged the results so the decision just hung in the balance so to speak.

Now the calculation is a bit long and arduous but that's where the marks are. But we also work with graphical calculators calculators and there is a function that gives you the answer direct. Just punch in all the numbers, hit the button and there it is (actually a probability that the difference in

results might have occurred by chance.)

Now I suspected it wouldn't be exactly the same answer as I had calculated because the maths I was showing the students was a bit simplified. There is one correction that needs to be made concerning making unbiased estimates and another for small samples. But even after applying both these I still did not get exactly the same answer.

So looking more deeply I could see the difference was in the calculation of an aspect called "degrees of freedom". Normally you just add the number of samples (less one) together so I would assume the degrees of freedom to be 23. Yet the calculator was telling me the degrees of freedom were 15.4.

Now I'd never come across a "decimal" value before so I read more. Sure enough there is a further process called "Welch's Correction" – a tedious bit of calculation that modifies the straight addition of $10-1+15-1$ to give the somewhat surprising answer of 15.4

The problem is that in this particular case Welch's correction isn't a very

good one. It gives far too conservative an answer. But who knows that?

Buried deep in the software is a special calculation which is sometimes applicable and sometimes isn't – depending how different the sample sizes are. But it apparently applies this correction to all calculations. And in some cases it gives the wrong answer. And it got me thinking.

I have a friend who sits on a panel approving applications for Chartered Engineer status (he's my age – nearly 60). He commented to me that there is a whole generation of push button engineers believing what their calculators tell them.

Personally I'd much rather look up a statistics on a chart than peek at a single answer on a screen because I can see the shape and spread of my statistic.

When I worked in industry our Chief Engineer clung to his slide rule long after the rest of us had switched to calculators and I now see why. The slide rule gave him the scale and spread of the problem – he knew what he was doing and personally trusted his answer.

Maybe some software engineer looked up Welch's correction in a book and

not appreciating its flaws, then applied it to all calculations. Maybe that bit of software got marketed around all the calculators in the world years ago and now everyone's forgotten how it was put together.

How many other dubious processes are there buried deep in the system? Does some guy on a BP oil rig punch numbers into a calculator to undertake a risk analysis and believes the answer that the risk is low – relying entirely on what the calculator tells him?

Science fiction writers have warned for 50 years the dangers of handing over control to computers or robots. But we still did it – though in a much more subtle way than putting a super computer in charge of our missile systems. No we can destroy the world economy by just programming computers to buy and sell shares in a fraction of a second or package derivatives so no-one really knows what's going on any more. Remove the individual from the decision process and watch the meltdown.

Now where did I put my old slide rule?

Robert Goodhand