Communication and using maths and stats

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Communication

▶ There are many societal issues – e.g. climate change, artificial intelligence, disease modelling, and public health – which maths is vital to addressing.

▶ Many researchers in these areas are not mathematicians.

▶ These issues impact those outside the research community, so there is a need to engage and communicate with policymakers, mainstream media, and the wider public.

▶ Also to communicate the importance of curiosity-driven research.

Statistics in science and social science

▶ Often the need arises around the role played by statistics in experimental research.

▶ Statistics is part of the process of formulating a research question and guiding experimental design.

▶ Data analysis is part of the methodology.

▶ This provides insights for drawing conclusions and making predictions, and also feed into discussion of uncertainty, limitations, and reliability of results.

Who takes part?

▶ Ethical issues:
  ▶ Privacy and data protection issues.
  ▶ Is the research necessary and well designed?
 ▶ Will the participants' time/effort/inconvenience be effective in answering the research questions?

Research with human participants

- Informed consent means the participants give their consent to take part and are well-informed about what they are agreeing to.
- Needs to communicate
  - clear, comprehensive information about the study, its purpose and how it will work;
  - potential risks of taking part;
  - potential benefits of taking part;
  - that participation is voluntary, with the option to withdraw at any time without penalty.
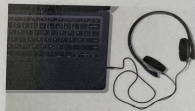
Who is impacted?

► When models are developed and used to make policy and practical changes.

► Figure is from Rycroft-Smith et al. (2024)

Problem context: designing new bus routes

ACTIVITY	MATHEMATICAL-ETHICAL QUESTIONS
Establish objective and constraints -agree on budget, time and resources available -decide which criteria to optimise for	-how might we decide on which users to prioritise? -whose constraints are we using and why? -is a solution possible? what compromises will have to be made?
Gather data -find out how people currently travel -find out how people would like to travel	-was the data collected fairly and with permission? -is the sample biased? -is there fair representation in the data? how do we know?
Choose model/algorithm -choose solution technique (AI or classical optimisation) -choose algorithm and model	-who chose the model/algorithm and why? -what assumptions and biases might be embedded? -if AI is used, who takes responsibility for ethical issues?
(Re)consider assumptions -ask more questions about potential users -make assumptions explicit and critique them	- what assumptions have we built into the system? -which assumptions hold and which do not? -how might we have potentially misread the problem context?
Collaborate with experts -find out more from a 'ground up' perspective -seek views which illuminate new problems/ potential flaws	-who knows this terrain well and could help here? -whose perspective have we missed? -what crucial issue have we failed to take account of?
Test and troubleshoot -trial ideas and be flexible and open to critique -support and embed solutions by troubleshooting	-what happens when things go wrong and how do we fix them? -who takes reponsibility for failure? -what happens when the context or constraints change?
These stages are not discrete or linear; they form an iterative design cycle	accordingly, the mathematical-ethical questions here can be posed at any stage and in any order

How are results communicated?

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  ▶ 27 litres is one and a half jugs? A jug of water holds 18 litres?
  ▶ The US population is about 340m, so "one in 10" is about 34 million people.

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  ▶ 27 litres is one and a half jugs? A jug of water holds 18 litres?
  ▶ The US population is about 340m, so "one in 10" is about 34 million people.

▶ Sense check:
  ▶ What is a U.S. resident's average water usage?
  ▶ What is the USA's total water usage?
  ▶ Essentially: is 435m litres a big number?
  ▶ The result might be horrifying, but the communication isn't helping get that across.

Polling

▶ "One in five young Americans thinks the Holocaust is a myth" (*The Economist*, 2023).

▶ Based on a YouGov poll.

Opt-in vs. random polling

▶ What are the inventives to participate?

▶ Pew Research Center used an online opt-in sample to ask opt-in respondents if they were licensed to operate a class SSGN (nuclear) submarine.

  ▶ 12% of adults under 30 claimed this qualification, significantly higher than the share among older respondents.
  ▶ In reality, the share of Americans with this type of submarine license rounds to 0%.

  (Mercer, Kennedy and Keeter, 2024)

▶ Re-running the holocaust denial research as a mail-based poll with probability-based sampling, they found 3%, not 20%.

How are results communicated?

▶ The output from mathematical and statistical modelling and analysis should be communicated clearly and accurately.

▶ Be aware that maths and stats can be used to mislead or confuse, or to give the impression of rigour where it does not exist.

Mathiness

▶ Romer (2015) refers to misuse of mathematics in economics as "mathiness" – "he doesn't mean that economics uses too much mathematics but that some economic theorists are pushing an ideological agenda and using fancy mathematics to disguise their intentions" (Harford, 2015).
  ▶ "They can redefine familiar words to mean unfamiliar things."
  ▶ "They can make unrealistic assumptions."
  ▶ "They can take hypothetical conclusions and suggest they have practical significance."
  ▶ "And they can do all these things with little fear of detection, behind a smokescreen of equations." (Harford, 2015)

Mathiness

The antidote to mathiness isn't to stop using mathematics. It is to use better maths ... Romer wants economists to use maths with "clarity, precision and rigour". Statistical claims should be robust, match everyday language as much as possible, and be transparent about methods. ...

Mathematics offers precision that English cannot. But it also offers a cloak for the muddle-headed and the unscrupulous. There is a profound difference between good maths and bad maths, between careful statistics and junk statistics. Alas, on the surface, the good and the bad can look very much the same.

(Harford, 2015)

Example: US trade tariffs

▶ 2nd April 2025 ("Liberation Day") the US instigated a number of protectionist import trade tariffs. (Guo, 2025)

Basic Approach

Consider an environment in which the U.S. levies a tariff of rate τ_i on country i and $\Delta\tau_i$ reflects the change in the tariff rate. Let $\varepsilon < 0$ represent the elasticity of imports with respect to import prices, let $\varphi > 0$ represent the passthrough from tariffs to import prices, let $m_i > 0$ represent total imports from country i, and let $x_i > 0$ represent total exports. Then the decrease in imports due to a change in tariffs equals $\Delta\tau_i * \varepsilon * \varphi * m_i < 0$. Assuming that offsetting exchange rate and general equilibrium effects are small enough to be ignored, the reciprocal tariff that results in a bilateral trade balance of zero satisfies:

$$\Delta\tau_i = \frac{x_i - m_i}{\varepsilon * \varphi * m_i}.$$

In a comparison with four other major cities, Nottingham is ranked second for overall satisfaction with the way the authority runs things.*

Local Authority   Overall satisfaction with the way authority runs things

Local Authority	Overall satisfaction
Nottingham City Council 2012	66%
Birmingham City Council 2009	68%
Bristol City Council 2011	36%
Newcastle City Council 2012	57%
Sheffield City Council 2009	45%

*Methodology and sample size may vary between councils

nottinghaminsight.org.uk/insight/library/citizens-survey.aspx 5
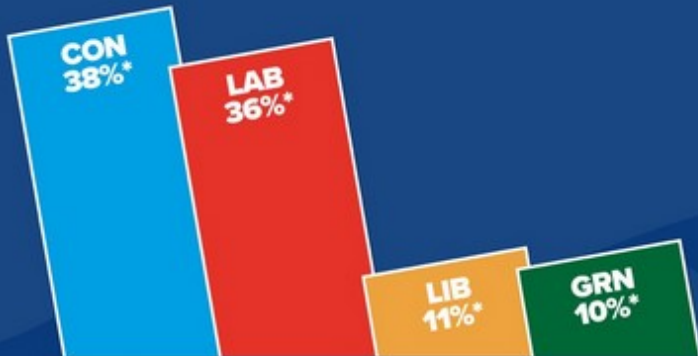
Only the Conservatives can seriously challenge Labour for control of Kirklees Council

Promoted by Adam Gregg on behalf of Damian Brook, both of Colne Valley Conservatives, Cliffe End Business Park, Huddersfield, HD3 4TG. *Kirklees wide vote share 2021 Local Elections

Colin Beveridge ▶ **South Dorset Labour Party**
Wednesday at 07:54 · 🌐

I just received a flyer for Mike Byatt as part of your election campaign that included a graph without any numbers or source of data on it. Please can you clarify where the 'latest data' comes from?
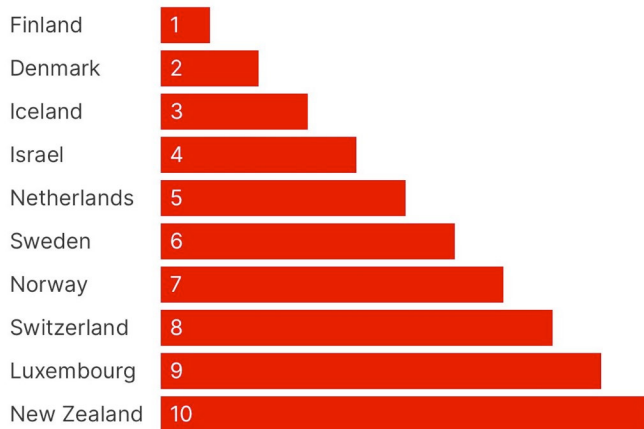
Like · Comment

Andy Blackwood I suspect you have enough experience of the murky world of party politics and elections to know that this graph was "created" to get a specific message across to voters. If you like, the 'data' was based on the conversations I had with an unspecified number of the electorate during the campaign.
about an hour ago · Like
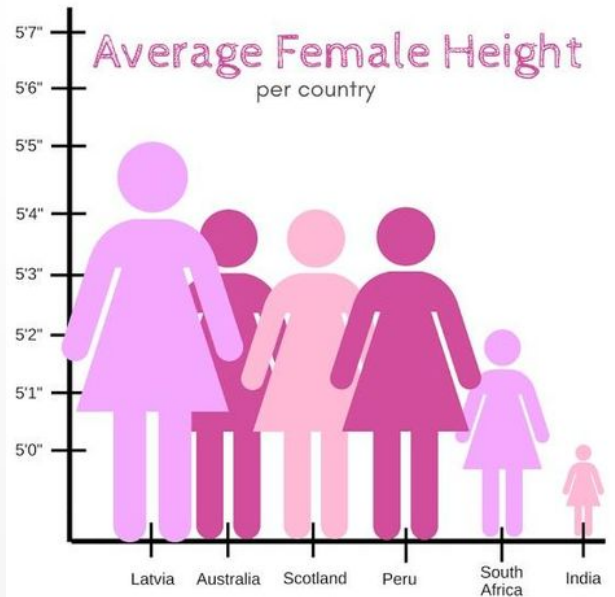
Data visulisation

▶ Be aware it can be easy to mislead with bad graphs even when this is not intended.

Top 10 Happiest Countries in 2023

This chart shows the top 10 happiest countries according to the 2023 World Happiness Report.

Country	Rank
Finland	1
Denmark	2
Iceland	3
Israel	4
Netherlands	5
Sweden	6
Norway	7
Switzerland	8
Luxembourg	9
New Zealand	10

Kilde: World Happiness Report

Average Female Height per country

Colour-blindness

▶ One issue with presenting data is whether all readers will be able to access this.

Weekly task

▶ You have now done ten weekly tasks.

▶ You should choose your best and do extra work this week to improve this, thinking about the feedback given across the ten pieces.

▶ If you feel you have not got a piece of work which reflects your best work, you may complete a new piece of research.

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