"New directions in statistics education - the impact of technology"

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Overview

1. David Vere-Jones influence
2. Changes in statistics in schools
3. First-year university and beyond?
4. Emergence of large and complex datasets
5. Impact of new data visualisation tools
6. Changing role of mathematics in statistics
7. Concluding comments

1. David Vere-Jones influence

"One of the most notable achievements of western societies in the last few decades has been the extension of modern education, including mathematics, to a very substantial proportion of the population"… "It is within this context that the movement for statistics education has taken root" (Vere-Jones, 1995, p.13).

- New Zealand school curriculum
  - Advocacy – with Geoff Jowett and Stan Roberts
  - University Entrance Board
    Convenor, Mathematics Steering Committee (1978 -85)
    Subject convenor, member National Consultative Comm. on Maths (-2004-)
    Mathematics with Statistics replaces Additional (Applied) Mathematics
- Promotion of women in statistics
  - Prof Campbell legacy (David – replaces as Professor of Statistics at VUW in 1970) '*special feature of statistics…breaks away from the vision of mathematics as a male-oriented subject*' (Vere-Jones, 1995)
  - Now 3+ women Professors of Statistics in New Zealand (1+ at Victoria)
- Promotion of statistics education as a field of research and practice
  - 16 Papers (1967-2001 – Russia, NZ and international), NZSA Prof Campbell Award (2009)
  - Royal Society and MORST reports (Mathematics in New Zealand: Past, Present and Future - 1998)
- International involvement
  - ISI Council Member 1984-7, Chairman of Education Committee 1987-91
  - IASE Interim Executive President (1991-1992) – David Moore first president 1993
  - ICOTS – ICOTS III International Program Coordinator, Editor of Proceedings 1991

2. Changes in statistics in schools

History

- Mathematics with Statistics paper introduced (1980)
- new emphasis on statistics in curriculum
- new Mathematics and Statistics curriculum (2007)

"Statistics is the exploration and use of patterns and relationships in data" (MOE, 2007)

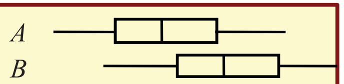
New content and pedagogy

- Informal inference TRLI project '*Building students' inferential reasoning: Statistics curriculum Levels 5 and 6'* (Maxine Pfannkuch, Chris Wild et al) Years 9-10
- Bootstrapping TRLI project *"Bootstrapping statistical inference reasoning"* (Pfannkuch, Wild, Forbes, Harraway et al)
- Randomisation – as above

Informal inference "How to make the call" by School level

Thanks to Prof. Chris Wild, Department of Statistics, University of Auckland

Curriculum Level 5: *the 3/4-1/2 rule*



If the median for one of the samples lies outside the box for the other sample
(*"more than half of the B group are above three quarters of the A group"*)
make the claim "***B tends to be bigger than A***" back in the populations

[Restrict to samples sizes of between 20 and 40 in each group]

Majority of one to the right of "the great whack" of the other

Some notes about the rules

Curriculum Level 5: *the 3/4-1/2 rule*

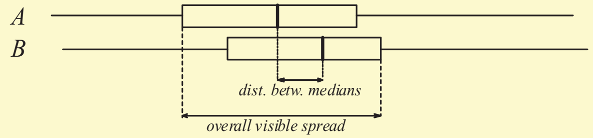
- The intuitive idea here is "the majority of the *B* group is bigger than the 'the great whack' of the *A* group"
- *Technical aside*: sampling variation alone does not often produce shifts large enough to trigger this rule
  - about 15 times in 100 for samples of size 20, 7 times in 100 for samples of 30, 3 times in 100 for samples of 40, 1 times in 2,500 for samples of size 100.

Exercise: Is median of boys bigger than that of girls using this rule?

"How to make the call" by School level

Thanks to Prof. Chris Wild, Department of Statistics, University of Auckland

Curriculum Level 6: *distance between medians as proportion of "overall visible spread"*



Make the claim ***B tends to be bigger than A*** back in the populations
if distance between medians is greater than about ...

1/3 of overall visible spread for sample sizes of around **30**

1/5 of overall visible spread for sample sizes of around **100**

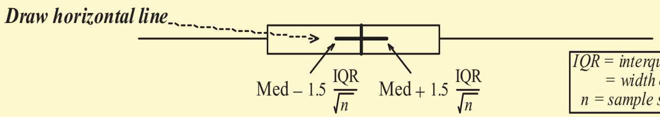
[***Could also use*** 1/10 of overall visible spread for sample sizes of around 1000]

Exercise: Is median of boys bigger than that of girls using this rule?

"How to make the call" by School level

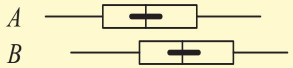
Thanks to Prof. Chris Wild, Department of Statistics, University of Auckland

Curriculum Level 7: *based on informal confidence intervals for the population median*

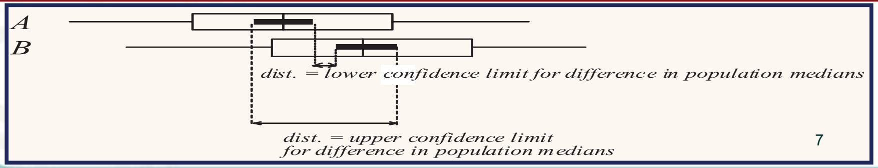


IQR = interquartile range = width of box
n = sample size

Make the claim ***B tends to be bigger than A*** back in the populations



if these horizontal lines (intervals) do not overlap



On to formal inference

Under some assumptions,
such as roughly equal sized samples we can construct

Intervals for the difference in medians
that we have 95% confidence cover the difference in the population medians

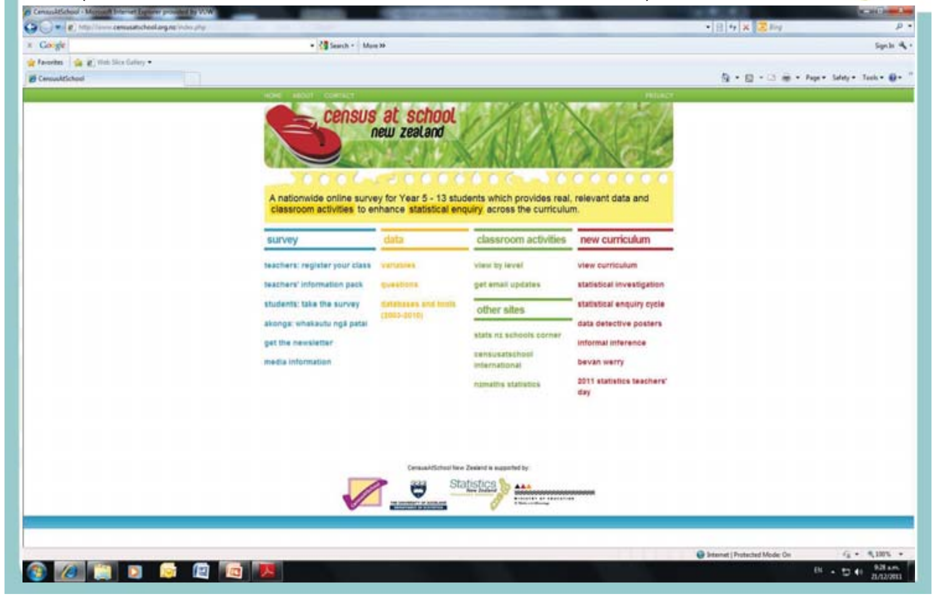
The width of this interval is roughly

$$\pm 1.57 \frac{IQR}{\sqrt{n}}$$

These 95% confidence intervals can be used to construct notched box plots.
Say medians are different if notches don't overlap

Use of CensusAtSchools in teaching

(child of the 1990 NZSA Children's Census at ICOTS III)



3. First-year university and beyond?

Courtesy of Prof Jenny Brown Canterbury (Delta Conference presentation, 2011)

- Large courses (1000+ students, more at Auckland)
- Are we meeting the needs of these students?
  (Few intend to major in statistics, highly variable backgrounds)
- Focus on teaching the majority not the major

"This is your last chance to teach statistics to tomorrows leaders"

"What is it they need to know?"

Who will they become?

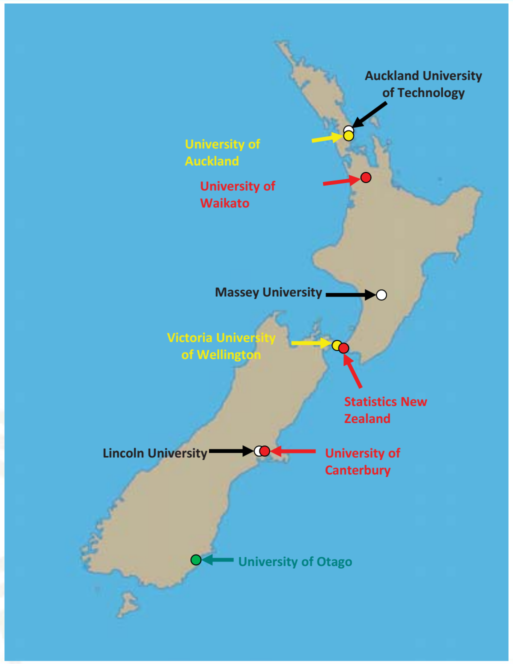
What statistics do they need?

Changes in what and how we teach

- Learning outcomes Critical statistical thinking
  - Use PPDAC cycle (Problem, Plan, Data, Analysis, Conclusion – Wild & Pfannkuch)
  - Analyze and make judgments from problems
  - Understand uncertainty
  - Understand sample data from a population
  - Create sensible graphs
- Teaching style
  - Lectures (and videos available for review) - not the primary means of engagement
  - Weekly online tutorials
  - Examples classes
  - YouTube clips of examples
  - Teaching rooms - tutor-help available all day
  - Study groups
  - Forum discussions in Moodle
  - Online practice (Moodle) tests
- Assessment
  - Many low-stakes assessment (1-2% of final mark)
    - Online tests
    - Written assignments
  - Final exam

Honours paper in Official Statistics

Vere-Jones, D. (2001) Official Statistics and the university statistics programme. *Proceedings of the Golden Jubilee Celebrations of the International Statistical Education Centre.*



5 participating universities + national statistics office

3 institutions teaching only

1 institution with students only (no teaching)

2 institutions with students and teaching

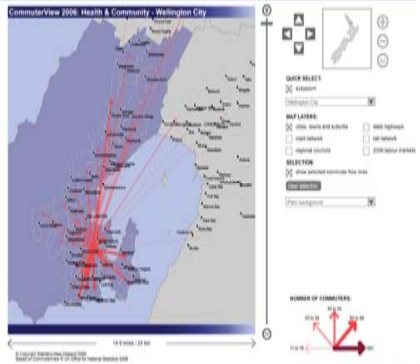
Honours paper - Course Outline

Institution/dept	Topic
Statistics NZ & Auckland Stats	Overview, underlying principles, key case studies (observational, not experimental) advantages and limitations
VUW/ Statistics	Administrative and survey data – sample/population, measurement and framework concepts. Case studies for variables, collection
	ASSIGNMENT – 20%
Waikato/ Demography	Demography – fertility, mortality, migration – age structure analysis
	Demography –population projections, policy implications, life tables, cohorts
	ASSIGNMENT – 20%
Auckland/ Statistics & Social Science	Health statistics – age standardization, morbidity statistics, registers, data sets, data access, relative risks, odds ratios, other risks, confounding
	Other social statistics– registers, data sets and data access
	ASSIGNMENT – 20%
Canterbury/ Stats	Data Visualisation and GIS
Victoria/ Stats	Survey design and analysis (cross-sectional, longitudinal, rotating panel), data cleaning, editing/imputation, post stratification, survey weights
Auckland/ Stats	Data matching
	ASSIGNMENT – 20%
Statistics New Zealand (& Waikato)	Economic statistics, time series, seasonal adjustment, indices - CPI, PPI National accounts GDP
	ASSIGNMENT – 20%

- Pilot in 2011 of 29 students (7 Otago, 4 VUW, 18 Auckland)
- Dedicated website, Matrix-grid video-conferencing, Video recorded lectures
- All students completed all assessments (grades B- to A+)

4. Emergence of large and complex datasets

- Integrated data sets (surveys, administrative data, etc.)
  e.g. LEED – Longitudinal employer-employee dataset
- Complex surveys (longitudinal, etc)
- Large data sets, some in real time (New questions, new forms of display)
  e.g. Analysis of Census commuting data ('Where do you live?' and 'Where do you work?') Table size: Area Unit level > 3 million cells, Meshblock = 2 billion cells!!!

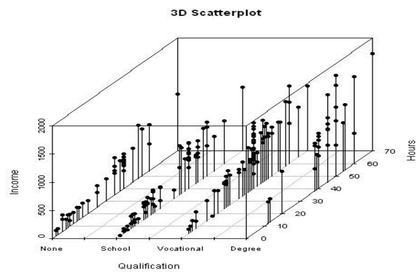


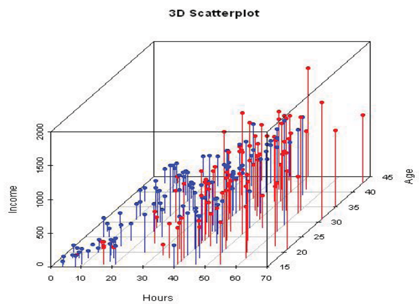
5. Impact of new data visualisation tools

- Use of data visualisation to teach statistical concepts
  - Readily available free simulation tools
  - New forms of dynamic and interactive graphics
- Rapid growth of geo-visualisation and geo-statistics

Using data visualisation to teach statistics concepts – Example 1: Multiple regression

(a)Weekly income by hours worked and qualification level
3D data – use pin graph to 'see' interactions ('R' graphics)

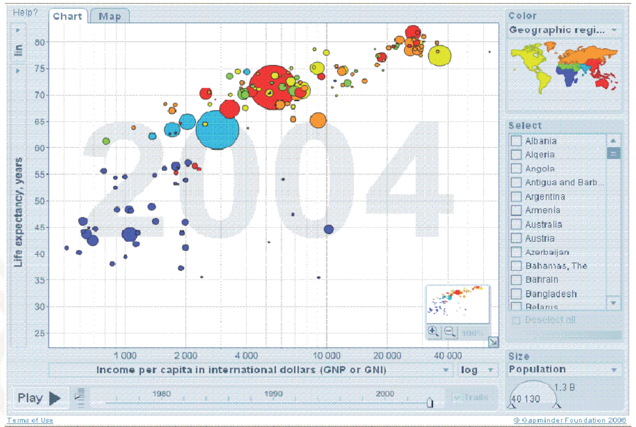




(b) Weekly income by hours worked, sex and age
4D data – use colour, etc. to examine model(s)
(Statistics New Zealand Income Survey – Synthetic Unit Record File data)

5D and beyond: Gapminder/Trendanalyser

Combines geography, history, demography, econometrics and social data (Creator: Hans Rosling)



http://www.gapminder.org OECD data

Example 2: Understanding price indices

Relatively easy to show price change for one commodity as:

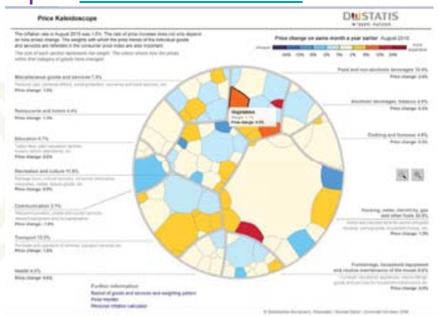
$$\frac{current\ price}{reference\ price} \times index\ reference$$

More difficult to understand 'weighted' index even for simple Laspeyres Index where index for period t on base period o is:

$$Index = \frac{\sum P_t Q_o}{\sum P_o Q_o} \times 1000$$

where Q is the quantity (weight) and P the price of the item.

Price kaleidoscope www.destatis.de

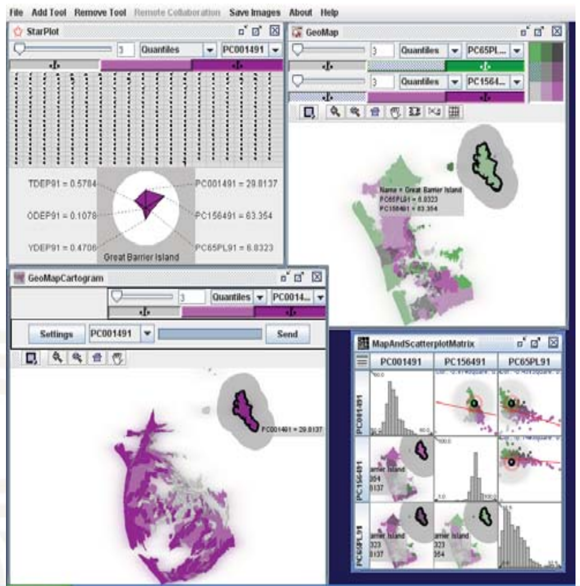


Example 3: The 'momentum' effect in demography

Animated population pyramids

Example 4: Integrated maps, graphs and analysis

N ew software –GeoVista (with Auckland 2006 Census data)



Some policy uses of GeoVista in New Zealand

(Penn State University software: http://www.geovista.psu.edu/grants/cdcesda/)

- alternative presentations of cancer data for health professionals
- geographical correlation between crime victims and the 'fear' of crime
- displaying the co-variation of occupancy rate and dwelling density - identifying where both are high giving high population densities; and also where low occupancy rates reduce the population density impact of high dwelling density.
- analysis of labour market clearing – the propensity of local people to get the employment they want and of local employers to get the labour they need.

de Róiste, M., Gahagen, M., Morrison, P., Ralphs, M., Bucknall, P. (2009). *Geovisualisation and policy: exploring the links.* Official Statistics Research Project Report. Statistics New Zealand.

- exploration of household based crowding in Auckland - its relationship to ethnicity

Goodyear, R., Fabian, A., Hay, J. (2011). *"How many is a crowd?" Which crowding index works best for New Zealand?* Working paper for Statistics New Zealand, Wellington, New Zealand.

6. Changing role of maths in statistics

- Emphasis on concept rather than mathematics
- Becoming free of '*the tyranny of the computable*' Cobb (2007)
- Decision-making in the context of real questions
- Probability basis to statistics decision making?

e.g. Housing Insulation policy ($500+ million investment)

Effect of insulating existing houses on health inequality:cluster randomised study in the community, Philippa Howden-Chapman et al (BMJ, 2007)

Table 5 | Temperature and relative humidity in a trial of insulating houses

Outcome*	Before intervention: Intervention group	Before intervention: Control group	After intervention: Intervention group	After intervention: Control group	Difference (95% CI): Unadjusted	Difference (95% CI): Adjusted for baseline score
Temperature (°C)	13.6	13.2	14.2	13.4	0.40 (0.10 to 0.70) P=0.05	0.50 (0.03 to 0.96) P=0.04
Relative humidity (%)	68.6	68.3	64.8	66.9	−2.4 (−3.70 to −1.10) P=0.05	−2.3 (−4.20 to −0.30) P=0.02
Average hours/day <10°C	3.25	4.02	2.26	4.47	−1.44 (−2.12 to −0.76) P=0.007	−1.66 (−2.56 to −0.76) P=0.001
Average hours/day >75% relative humidity	6.81	6.78	4.57	6.69	−2.15 (−3.23 to −1.07) P=0.01	−2.13 (−3.38 to −0.88) P=0.003

*Measured for both years on a subsample.

Table 7 | Self reported SF-36 results in a trial of insulating houses. Results are mean score in adults who had data for both years, unless stated otherwise

Scale	Before intervention: Intervention group	Before intervention: Control group	After intervention: Intervention group	After intervention: Control group	Difference (95% CI): Unadjusted	Difference (95% CI): Adjusted
Social functioning	69.2	69.3	78.4	72.3	6.1 (3.9 to 8.4) P<0.0001	6.2 (3.8 to 8.6) P<0.0001*
Role emotional	63.1	62.4	77.5	66.7	10.8 (7.2 to 14.5) P<0.0001	10.9 (7.1 to 14.6) P<0.0001*
Role physical	52.5	52.2	70.0	58.8	11.2 (7.4 to 15) P<0.0001	11.8 (8.0 to 15.5) P<0.0001*

*Adjusted for score at baseline, age group, sex, ethnic origin, household, and region.

Questions:

Practical versus statistical significance?

Power of many significant differences?

Actual p-values versus (95%) confidence intervals?

7. Concluding comments

We are in a new world with

- different modes of teaching and assessment
- new collaborations (across university, government and university, etc.)
- use of visualisation rather than mathematisation
- growing importance of time and place (geography) in data
- need to establish link between problem criticality and statistical significance (and confidence)

Are we up to the challenge – the big questions?

- should we ever ignore time and geography when we analyse data?
- can we justify our emphasis on 95% (and 99%) confidence intervals

A return to the view of statistics espoused by Laplace?

'*common sense reduced to numbers*' (cited in Vere-Jones, 1995)