ICOTS 10 京

The Japan Statistical Society

Combining 360 degree reflections for looking forward

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Reflections?

Learning in teaching

- ☐ Reflective practice: analysing, evaluating, synthesizing
- ☐ Evidence of effectiveness/impact and non-effectiveness/non-impact
- ☐ **Listening and observing** students, reading students' work
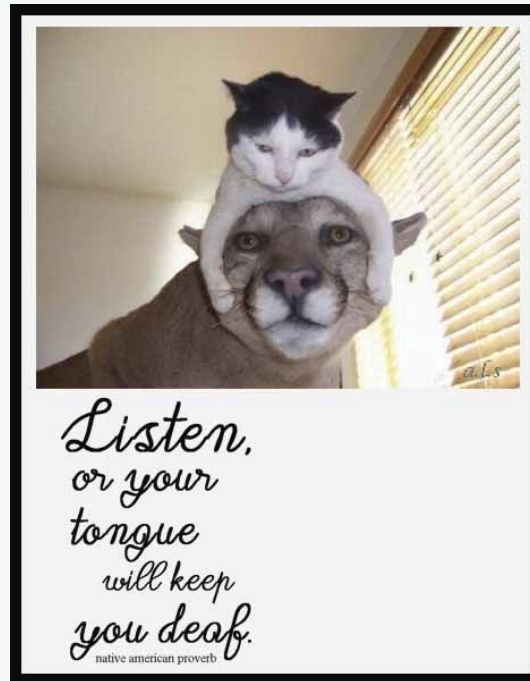- ☐ Asking and exploring why

Teacher:
"Why are you talking during my lesson?"

Student:
"Why are you teaching during my conversation?"

Most people do not listen with the intent to understand. Most people listen with the intent to reply.
Stephen R Covey

Listen, or your tongue will keep you deaf.
native american proverb

Every good conversation starts with good listening
Mike Arauz

360 degree?

- **Statistics:** science of variation, data, uncertainty, questioning of models, assumptions and interpretations

- **Critical importance lies in:**
    - pervasiveness
    - universality of concepts and thinking
    - power in specific contexts – across disciplines, business, industry, government and society
    - can be a driver, partner or servant, but from the most theoretical to the most applied, its roots lie always in real problems.

360 degree?

- **As we do with students, we need to do with users, refuters, collaborators, authors, dissenters, across all disciplines**

  ☐ **listen, observe, read, reflect and analyse**

Hence today I will try to give VOICE **to some listening, observing, reading from 360 degrees (but no singing)**

Outline

- **Input sources**

- **"Data literacy"**
  "Data science"
  "Big data"

- **Bit of history**
- **Developments over past few decades – the good**
- **Some challenges for us – the bad**
- **Elaborations on some of the challenges**

- **Some ways forwards**
- **Opportunities**

Some recent sources

International Statistical Institute
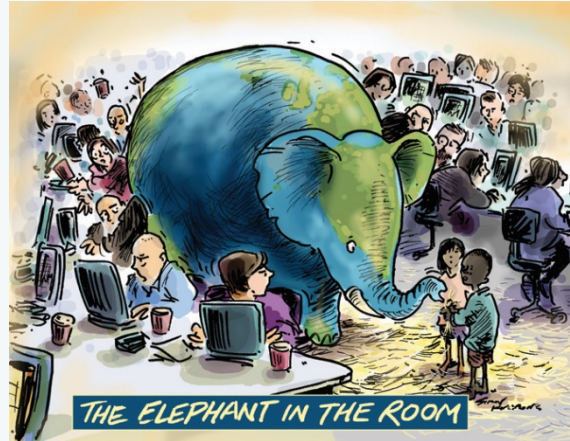
WSC's, RSC's, ICOTS, OZCOTS

TEACHING STATISTICS
An International Journal for Teachers

Co-Editor, 2014-2016
Editor, 2017-

Teaching Statistics first appeared 1979, published three times a year
Published by the Teaching Statistics Trust.
Teaching Statistics is intended for all those who teach statistics to students aged 9-19 years. The emphasis is on good practice in teaching statistics and statistical thinking in any context, whether in statistics subjects/courses/modules or in other disciplines such as economics and business, biology and health sciences, technology, psychology, mathematics and any area which uses statistics.

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

- UN World Data Forum: 2017, 2019
- UN Global Network of Institutions for Statistical Training (GIST)

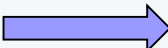# Less recent sources

- **1976: Counsellor in maths & stats**

1972-2011:

- **large, small classes across disciplines, levels…..**
- **teachers, schools, enrichment, curricula, resources…….**
- **learning support……..**
- **IASE, SSA, RSSCSE, ICOTS, OZCOTS, F'ship, HEA**

Organising computing labs for introductory "service" statistics 1980's

"Excel is a statistical health hazard"

Authentic learning of data investigations

- **1994-2011: semester-long free-choice full data investigation embedded in large introductory statistics courses in engineering, all sciences, IT and mainstream statistics programs**
  - ☐ **"Set" data and contexts, no matter how real, can't provide experience of *setting up, investigating, reporting***
  - ☐ ***Motivation to find tools***
  - ☐ ***Ownership* of data and context ⟶ engagement**

Student "wow!"

- * ownership
- * visualisation + exploration
- * tool empowerment within complex (>5 variables)
- * student judgement + communication

Entice	Grab
Excite	Keep
Empower	Maintain

Student choices: > 5000 projects!

Just a few!

- The three minute pop song
- Length of corporate employee phone calls
- 24 hours in a service station
- Lift or stairs?
- Aircraft noise levels
- Go go go!
- Human curiosity
- Death by statistics
- Holding breath
- Where are all the single people?

Crash testing stubbies

Egg strengths

Human curiosity

Many effects on learning and teaching

- **Choices of topics illustrate types of examples in which students want to see how statistical thinking and techniques can help**
- **Improved overall results**
- **Past students remember their projects - as do staff**
- **Discovered what students need**
- **Discovered what engages students.... *"get students to the sexiest, most useful techniques faster & more effectively…" Wild, 2006***
- **Significant curriculum re-development to better reflect**
  - ☐ **learning needs**
  - ☐ **real statistical problems**
  - ☐ **modern statistics**
  - ☐ **statistical practice**

Lessons learnt plus investigations and data embedded in *Mind on Statistics*, MacGillivray, Utts & Heckard, 2nd edn (2014), Cengage

"Data literacy" "Data science" "Big data"
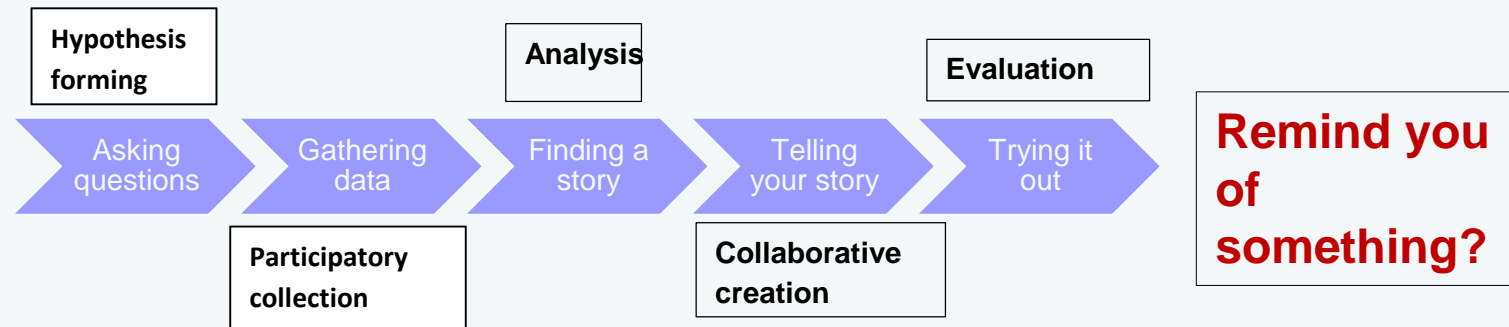## *Statistics and its teaching even MORE important*

- **Diversity of perceptions of relationships between 'data literacy' and 'statistical literacy'**
  - "everyone knows they're different"
  - "everyone knows they're the same"

- **Views of 'data science' and 'statistical sciences'**
  - *Data scientists are statisticians who make meaning from data*
  - **need statistics in data science; data science in statistics**
  - **coding/programming in data science? Reminders of long-lasting questions re maths in stats**

- **'Big data' – complex and rich**
  - **Multivariate, variable diversity, and/or many cases**
  - **Data quality, high level technological data management**

Some recent descriptions of data literacy (from 1st UN WDF)

- *Data literacy is the ability to read, create and communicate data as information and has been formally described in varying ways.*

- *The desire and ability to constructively engage in society through and about data* http://datapopalliance.org/item/what-is-data-literacy/

- *Data literacy: ability to interpret, evaluate, and communicate statistical information…how statistical information is created, encompassing data production*

- **Diagram below is from** *Tips and Tricks for Creative Data Literacy* **(Bhargava,** http://undataforum.org/WorldDataForum/wp-content/uploads/2017/01/TA4.06-un_data_summit_-_bhargava.pdf **)**

Hypothesis forming		Analysis		Evaluation
Asking questions	Gathering data	Finding a story	Telling your story	Trying it out
	Participatory collection		Collaborative creation	

Remind you of something?

Some descriptions of statistical literacy

- *Good "statistical citizens": able to consume information that they are inundated with on a daily basis, think critically about it, and make good decisions.* Rumsey (2002)

- *People's ability to interpret and critically evaluate statistical information and data-based arguments appearing in diverse media channels, and their ability to discuss their opinions regarding such statistical information* (Gal 2000)

- *Become much more critical about the way data are produced, the way data are presented and the way data are interpreted.*

Descriptions can be useful; definitions and de-limiters usually misleading.
Clue to interpret some descriptions is in the context.
But why the ignorance and denial of statistics?
To be continued….

"Big data analytics"; "data science"; training

From my ISI President's message October 2017

In an article on employment in workplaces increasingly driven by 'big data' and 'big data analytics'.

- **Commenting on the various 'hybrids' of skills and backgrounds needed**

- **Not once did the word statistics appear, but the only workplace person quoted was a statistician, who was also explicitly identified as a statistician!**

- **The statistician stressed the need for ability to analyse and communicate as well as statistical and IT technical skills**

- **It was very clear that the emphasis was on key skills that statistics professionals and educators have been highlighting for decades, including collaboration, communication, and interpretation of data in context.**

Absence of explicit recognition of value of statistical (and mathematical and technical) skills not new

- **Advice for decades to job-seeking graduates:** *look for skills in ads; look for 'analyst'.*

- **Student portfolios: identification of skills and awareness of broad & technical skills**

- **Two decades ago, I set up double degree in maths/stats and IT.**
  - **Those graduates went everywhere**
  - **Feedback included:**
    - **tackle anything; foundation for further learning**
    - **value of statistical learning which reflects the *practice* of statistics**

Articles also emphasize do not want production line of hybrid graduates: want sufficient diversity of graduates with balance+specialisation to work in effective teams.

Bit of history: ISI & IASE

- **In 1948, IS1 President Stuart Rice set up ISI Education Committee**, increasing ISI's mandate to undertake educational activities and collaborate with UNESCO and other UN agencies.

- **UNESCO grant to ISI for govt statistical training: ISEC set up in India, 1950, by P.C. Mahalanobis, has trained > 1500 from >80 countries.**

- **In 1970's, ISI increased attention to promoting statistics education in schools and universities. ISI Education Committee established task forces.**

- **Task Force on International Conferences in Statistical Education (ICOTS). ISI Committee's Roundtable conferences commenced in 1976. ICOTS commenced in 1982.**

- **Task Force on Teaching Statistics at School Level (TOTSAS), led initially by Vic Barnett**

Bit of history: ISI & IASE

- **TOTSAS group established regular newsletter (International Statistical Education newsletter). This lead to Vic and Joe Gani setting up the Teaching Statistics Trust to establish the journal *Teaching Statistics* in 1979**

- **Warren Gilchrist & Vic established the first (UK) Centre for Statistical Education in 1982 with its first Director, Peter Holmes, now sponsor of *TS* prize to highlight excellence in motivating practical classroom activity.**

- **International Association for Statistics Education (IASE) established 1992, one of 7 ISI Associations. (Vere-Jones, 1994).**

- **In 1994, an ISI committee established to stimulate the spread of quantitative skills around the world. In 2000 IASE invited to oversee it; called ISLP from 2002. In 2009, current structure of ISLP set up, including IAOS involvement**

Developments over past few decades

- **During 1980's and 1990's, many statisticians and statistics educators worldwide initiated & implemented variety of changes**
  - ☐ **in teaching statistics at university, particularly introductory levels across disciplines, & at school level.**
  - ☐ **in workplaces & community.**
  - ☐ **In statistics education research.**

- **Much reported in papers, at conferences, particularly since 1990 (ICOTS3)**
  - ☐ **ICOTS, IASE satellites & roundtables**
  - ☐ **SERJ (started 2002) JSE (ASA), *Teaching Statistics*, ISR & statistics journals (American Statistician, JRSS, etc)**

Developments over past few decades

- **Advocacy of**
  - **Data-driven concepts and statistical thinking**
  - **Real, 'large' contexts and data: simple within complex**
  - **Statistics in its own right (maths is servant)**
  - **Technological and data systems know-how**
  - **Student ownership and constructivism**

Some examples

- **UK**
  - □ **PDPD (Plan, Data, Process, Discuss) 1970's-current**
  - □ **STEPS in mid '90's**
  - □ **RSSCSE and CensusAtSchool**
- **US**
  - □ **"Statistics Education Reform"**
  - □ **GAISE (2005, 2007, 2016)**
  - □ **Advanced Placement**
  - □ **USCOTS (biennial since 2005)**
  - □ **New emphases e.g. randomisation 'movement'.**
- **NZ**
  - □ **PPDAC (Problem, Plan, Data, Analyse, Conclusion)**
  - □ **School data curriculum: bootstrapping, visualisation**
  - □ **Technology: iNZight; GENSTATS for schools**
  - □ **Apps, certificate in official statistics**

Some examples

- **Japan**
  - **Statistics in industry – statistics+engineering – data science**
  - **Japanese Inter-university Network For Statistical Education**
- **South Africa**
  - **Maths4Stats: reversing history**
  - **ISIbalo Capacity Programme (2009-)**
  - **School curricula; prof dev**
- **Australia**
  - **Student projects; enquiry/inquiry oriented learning (IOL); real contexts, data, probability**
  - **OZCOTS (approx biennial since 1998)**
  - **1/3 of national school maths curriculum P-10**

- **Advocacy from professional statisticians**
  - **'greater statistics'**
  - **Workplace and professional preparation**
  - **Greater emphasis on broad statistical thinking & outreach**

Long-time advocacy from statisticians

- **Box (1976) – Joiner (2005)**

- **Vic Barnett (1986)**
  - ☐ **"we see, tied up together, the role of the statistician as consultant, consultancy as the stimulus for research in statistics, and consultancy as the basis for teaching statistics".**

- **Authentic experience of full statistical investigation process**
  - ☐ **Cameron (2009) builds on Chambers' (1993) 'greater statistics'***
  - ☐ **comments that "*such training is an appropriate foundation for most statisticians wherever they may be employed.*"**
    - ■ **Note: part of the pyramid model**

  - ☐ *** Donoho (2017) 'greater data science'**

Long-time advocacy from statisticians

- **Authentic experience of full statistical investigation process**
  - ☐ **Kenett & Thyregod (2005) 5 steps in statistical practice**
    - *"important to take part in collection of data, or at least have the opportunity to watch data being collected or generated."*
    - *"encourage academic courses to cover the full 1–5 cycle....especially steps 1, 2 and 5."*

    - **1. Problem elicitation & preparation for tackling statistically**
    - **2. Preparing data (including planning, collecting, sourcing, identifying, organizing, validating…….)**

    - **5. Presentation of findings**

Statistical and data investigation process

- **Descriptions can depend on context. Examples from ICOTS10:**

Hiroe Tsubaki
- **SQC – Shewhart 1939**
- **Deming-Ishikawa: PDCA – gap analysis for problem finding**

Hilary Parker
- **Hadley Wickham: input – tidy – transform** **visualise** **– communicate**
  model

- **All descriptions**
  - **emphasize importance of everything <u>before</u> analysis and everything <u>after</u>**
  - **emphasize cycle: *building solutions to improve understanding of issues/problems***

- **Statistical analysis is essentially exploratory**
- **Need to teach communication of assumptions and findings**
  - **"Solution" ≠ the answer**
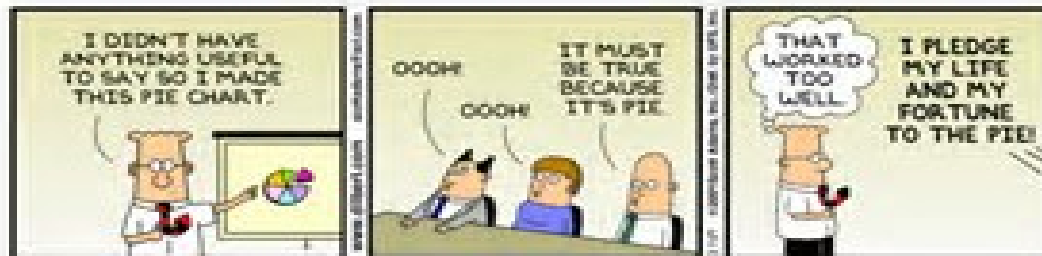
Some challenges for statistical community

Penetration insufficient within and across disciplines and levels.
Important to reflect on the why …..

- **Nature of Statistics & Statistics is BIG and EVERYWHERE**

- **Dynamic nature of Statistics: responds to data, technologies, disciplines, workplaces**

- **Technology: resources, use & how much to learn**

- **Need real, complex, many-variable datasets**

- **Visualisation: still too much focus on measures**

- **Assessment fears**
  - **Workload**
  - **Open-ended**
  - **Students "*won't do it right*"**

Some challenges for statistical community

- **Too much focus on new ways of learning old content & old sequencing**
- **Domination of 1 and 2 variables**
- **Not enough understanding/emphasis assumptions and models**
- **Need more on identifying variables (& types), cases**
- **Leftovers past their use-by-date**
  - ☐ **Return 'population' to its proper meaning**
- **"surface" referencing**
- **What tools can & can't do**
  - ☐ **Histograms, boxplots**

Some challenges for statistical community

- **Lack of coherent development**

- **Non-authentic experience of statistical investigation process**

- **Rigid, discipline-embedded approaches, top-down case studies**

- **Can't build on shaky foundations**

- **Perpetuation of norms**

- **Reclaim and reform learning of probabilistic thinking**

- **Research hypotheses vs statistical investigation**

- **Reflect on overall**
  - **Sometimes digging just produces a hole, and digging deeper gives mud**
  - **Sometimes climbing and looking around shows way forward**

Some challenges

- **'The' question & 'the' answer**

- **Not enough of the initial exploration/framing of issues, what data and what variables**
- **Too much rush to force into 'desired' form or get to 'desired end'.**

Some ways forward on investigations

- **Authentic experience**
  - **"What goes on in head?"**
  - **Students have to experience it.**
  - **"Empathy" - cultivate by role model: "let's see what we've got"**

- **Too much training for research: statistics and other disciplines**

- **Real data and real contexts but**
  - ☐ **Contexts must not dominate statistical learning**
  - ☐ **Contexts must be familiar/readily accessible to students**
  - ☐ **Staff research interests must be controlled**
  - ☐ **Beware teacher-centred, top-down or context-complex case studies**

- **Must use technology as used in practice of statistics**
- **Authentic learning and assessment**

Some challenges in other disciplines

- **Foundational understanding and content pedagogy knowledge insufficient across disciplines and educational levels**
    - **Can't build on shaky foundations**
    - **Perpetuation of norms in other disciplines**

- **Example: Tragic case of Sally Clark included**
    - **Lack of identification of issues and context**
    - **Inappropriate data for estimates of probabilities**
    - **Misunderstanding of conditional probabilities and incorrect multiplication of probabilities**
    - **More misunderstanding of conditional probabilities - 'Prosecutor's fallacy'**
    - **Withholding of (pathology) data/information**

Reclaim & reform probability learning

- **Language & visualisation paramount**
  - **Use probability diagrams with probabilities represented by areas or lengths or…**
    - Venn diagrams for events potentially misleading in statistics
  - **Extensive student experience of language ⟷ probabilities and of conditioning language**

- **Conditional probability BEFORE independence**
  - **All probabilities are conditional**
  - **Use data, estimates, beliefs…….**
  - **P(A and B) = P(A|B)P(B). Ban term 'multiplication rule'**

- **There are different ways of assigning probabilities, NOT different types of probabilities**
  - **Estimate**
  - **Model**   Combination of any of these
  - **Belief**
  - **Part of cycle of data investigation and models**

Some more challenges

- **Incorrect use of types of data**
- **Understanding discretization & effects**

- **Essentials of hypothesis testing are natural**
- **Multiple procedures and forcing into norms**
  - □ **overuse of t**

- **Lack of identification, questioning and visualisation of assumptions**

- **Over-analysis of old instead of reflection on what and why**
- **Forcing the new into the old**
  - □ **Simulating the boring**

Curriculum design

A design process

               A statistical consulting job

A statistical and data investigation process

Clients are students, staff, teachers, administrators, bean counters……..

Examples/anecdotes of design lessons from reflection+collaboration+trialling

- **From 6 weeks in each of MBA & electrical engineering**
  - ☐ **Learning to comment; discrete before continuous**
- **School curricula**
  - ☐ **"she omitted mode"; "she omitted line of best fit?"**
- **Postgraduates across disciplines**
  - ☐ **Variable types; role of statistics in research**
- **Introductory across disciplines**
  - ☐ **Get to multivariable & real empowerment as soon as possible**

Assessment design - for learning

Reflect what is of value

- **Workload fears**
  - ☐ **Can balance open-ended + multiple choice**
- **"Doing it right" fears**
  - ☐ **Need authentic student experience**
- **"Must be useful"**
  - ☐ **Students learn best in contexts that matter to them**

- **Multiple choice questions**
  - ☐ **naturally course-specific**
  - ☐ **tend to be highly dependent on local culture/conditions**

- **Criteria and standards for investigations**
  - ☐ **tend to be more universal**
  - ☐ **need exemplars**

Ways forward

- **Lessons from decades of work in statistics education**
  - biggest challenges lie in the nature and pervasiveness of statistics
  - universality of educational needs – statistics and data science
  - dynamic nature of statistics itself in responding to data, technologies, disciplines, and workplaces.

- **Challenges are as big as statistics but every bit makes a difference**
  - Challenges are ongoing

Variation, continuum within and across countries and disciplines

Ways forward: the how and collaboration

Observe, listen, communicate, reflect, think statistically

- **Enable coherent development**

- **Authentic working with other disciplines**

- **ASSESSMENT is key**
  - ☐ **Authentic and balance for efficient effectiveness**
  - ☐ **Real contexts, real data, complex data**
  - ☐ **Technology resources for learning and assessment**

- **Data science gives opportunity to renew push for authentic learning through statistical data investigation**
- **Authentic collaboration & sharing**

Thank you and here's to statistics and data!