

Mind the Gap: An incomplete picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

June 25, 2023
Maleny, Australia

A complete picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

June 25, 2023
Maleny, Australia

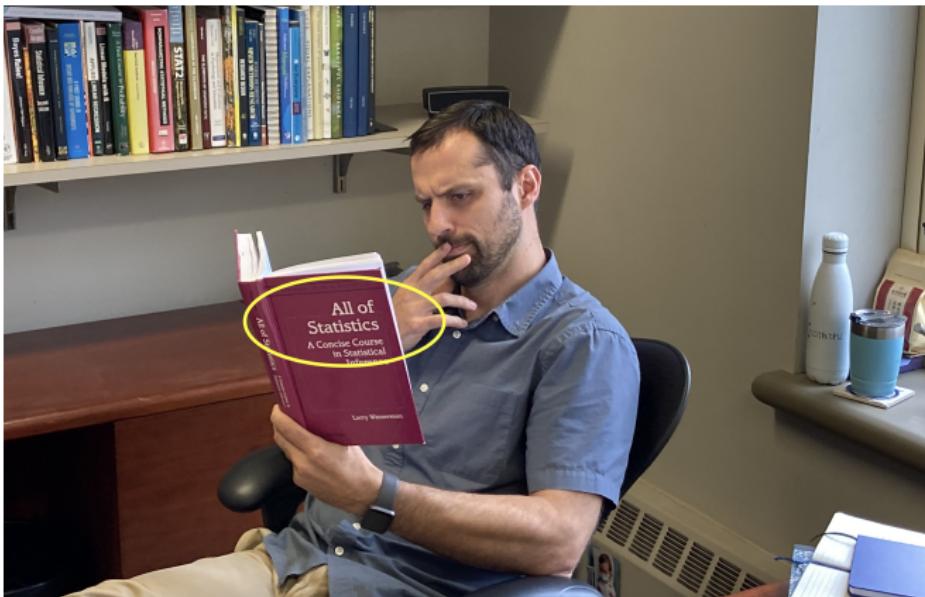


Figure 1: Getting ready to “Provide the perspective of the discipline...” as promised in the SRTL announcement.

- ... on “reconceptualising data and data-ing”

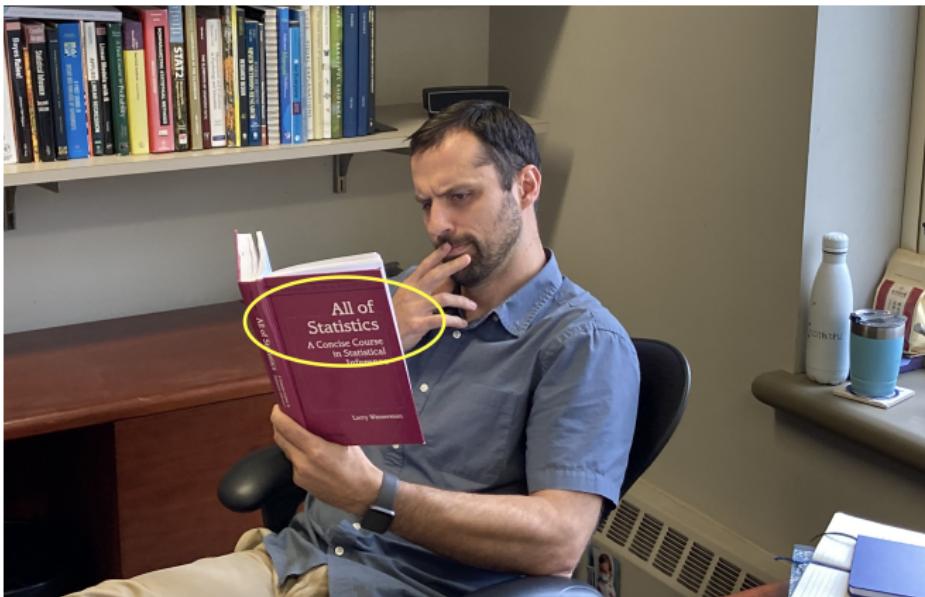


Figure 1: Getting ready to “Provide the perspective of the discipline...” as promised in the SRTL announcement.

- ... on “reconceptualising data and data-ing”
- “data-ing?”

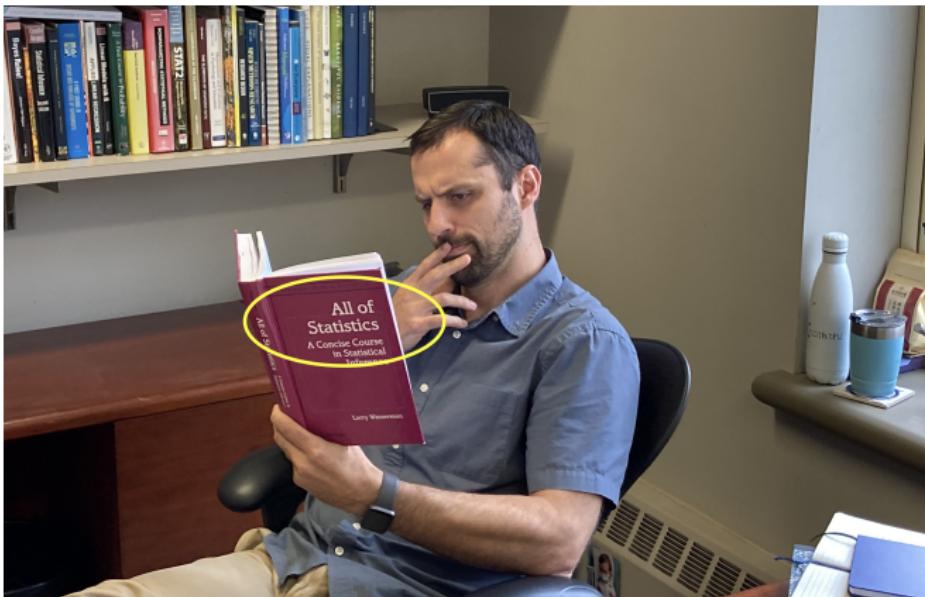


Figure 1: Getting ready to “Provide the perspective of the discipline...” as promised in the SRTL announcement.

- ...on “reconceptualising data and data-ing”
- “data-ing?”
- that wasn’t in the book...

A ~~complete~~ picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

June 25, 2023
Maleny, Australia

Mind the Gap: An incomplete picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

"Reconceptualizing
data ? data-ing"

June 25, 2023
Maleny, Australia



“Data...ing?”

- I'm usually not one to “verb” my nouns (then use as a gerund)

“Data...ing?”

- I'm usually not one to “verb” my nouns (then use as a gerund)
- [checks list of participants for a “grammarian-in-residence”]

“Data...ing?”

- I'm usually not one to “verb” my nouns (then use as a gerund)
- [*checks list of participants for a “grammarians-in-residence”*]
- but I've heard this kind of thing happens on Twitter

ADULTING

What Is the Meaning of Adulting?



- Gerund that stems from the use of the word adult as a verb.
- Means behaving maturely or acting like an adult.
- A lighthearted term used to highlight the mundane or comical activities being mature and responsible can bring about.

grammarist.com

Adulting is a fairly new gerund that stems from the use of the word adult as a verb. A gerund is a verb form ending in -ing that acts as a noun. *Adulting* simply means behaving maturely or acting like an adult.

Figure 2: image credit: Grammarist. URL:
<https://grammarist.com/new-words/adulting/>

But “Data” as a verb?

- I've heard of *data verbs*, just not “data” as a verb

But “Data” as a verb?

- I've heard of *data verbs*, just not “data” as a verb
- Amelia McNamara helpfully pointed out (to my surprise) this too has precedent!

But “Data” as a verb?

- I've heard of *data verbs*, just not “data” as a verb
- Amelia McNamara helpfully pointed out (to my surprise) this too has precedent!
- Who would do such a thing?

Jer Thorp



Roman Makhmutov

Jer Thorp is an artist, a writer, and a teacher. He was the first data artist in residence at *The New York Times*, is a *National Geographic* Explorer, and served as the innovator in residence at the Library of Congress in 2017 and 2018. He lives under the Manhattan Bridge with his family and his awesome dog, Trapper John, MD. *Living in Data* is his first book. You can sign up for email updates [here](#).

Figure 3: image credit: Roman Makhmutov¹

¹Thorp, J. (2021). *Living in data: A citizen's guide to a better information future*. New York: MCD, Farrar, Straus and Giroux.

Coming around. . .

- “the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept.”

Coming around. . .

- “the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept.”
- *This* resonates with me

Coming around. . .

- “the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept.”
- *This* resonates with me
- and it's starting to sound familiar. . .

What perspective can I offer?

The birth of an academic



Figure 4: (Academic) offspring of Joan Garfield & Bob delMas enters the world (of Statistics Education)

- if any of you know me, it's probably thanks to my parents
PhD advisors Joan Garfield & Bob delMas

The birth of an academic



Figure 4: (Academic) offspring of Joan Garfield & Bob delMas enters the world (of Statistics Education)

- if any of you know me, it's probably thanks to my parents PhD advisors Joan Garfield & Bob delMas
- there's plenty more to my upbringing before I ever got involved with Statistics Education, including lots that has almost nothing to do with academia!

Rebellious phase

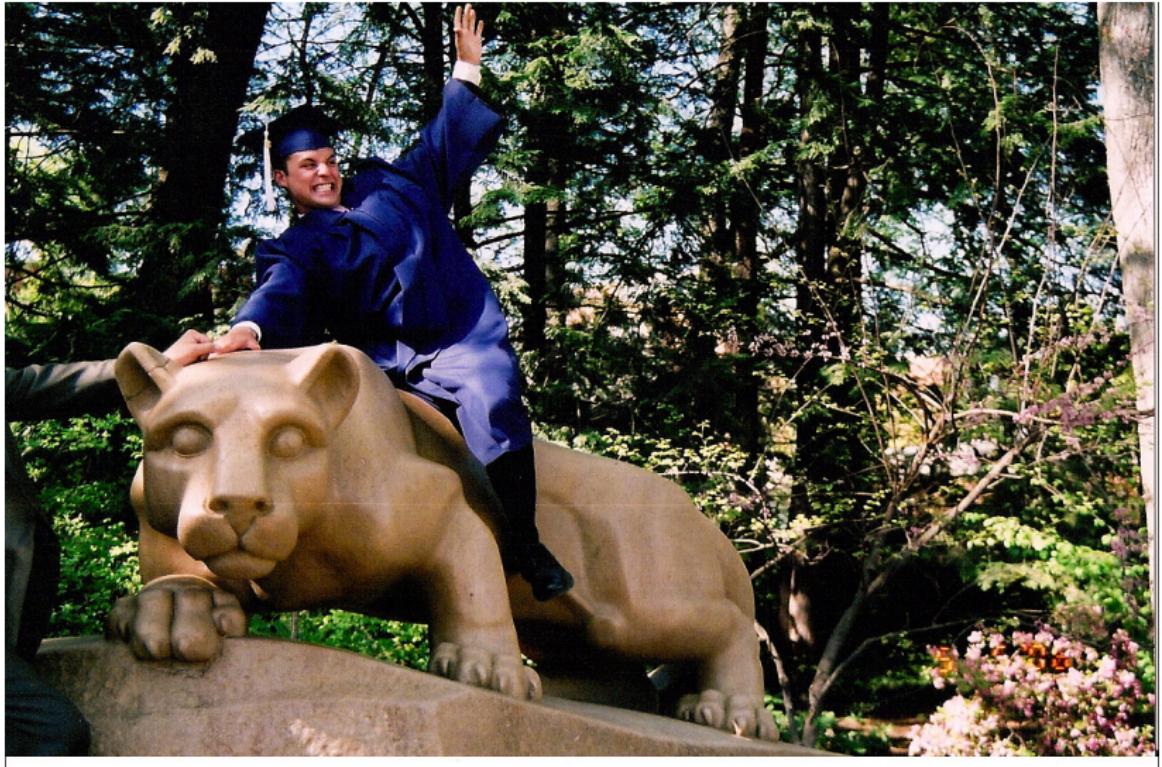


Figure 5: Who knows...

Social life



Figure 6: Sneaking onto an event at the stadium with a friend.

My actual Mum & Dad



Figure 7: Marian & Don Beckman

Got an education. . .



Getting more serious. . .

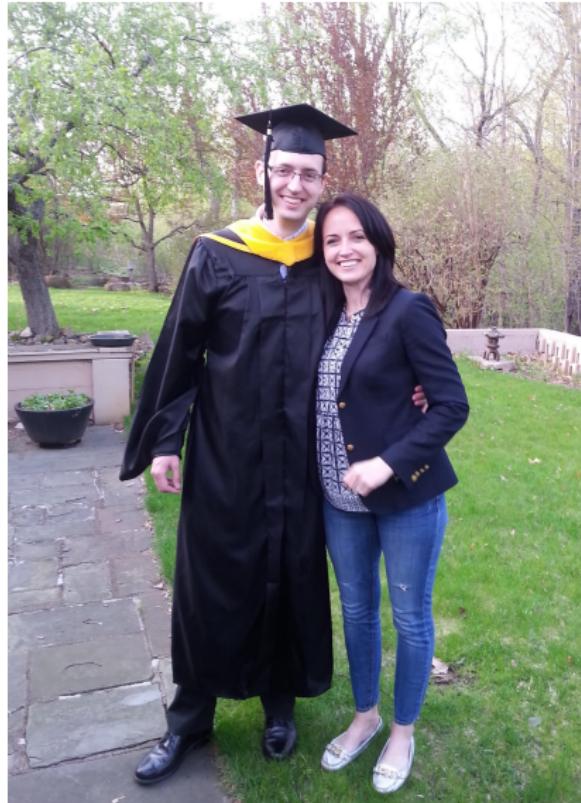


Figure 8: Met my wife in Minnesota and began a career in statistics.

8 years as statistician

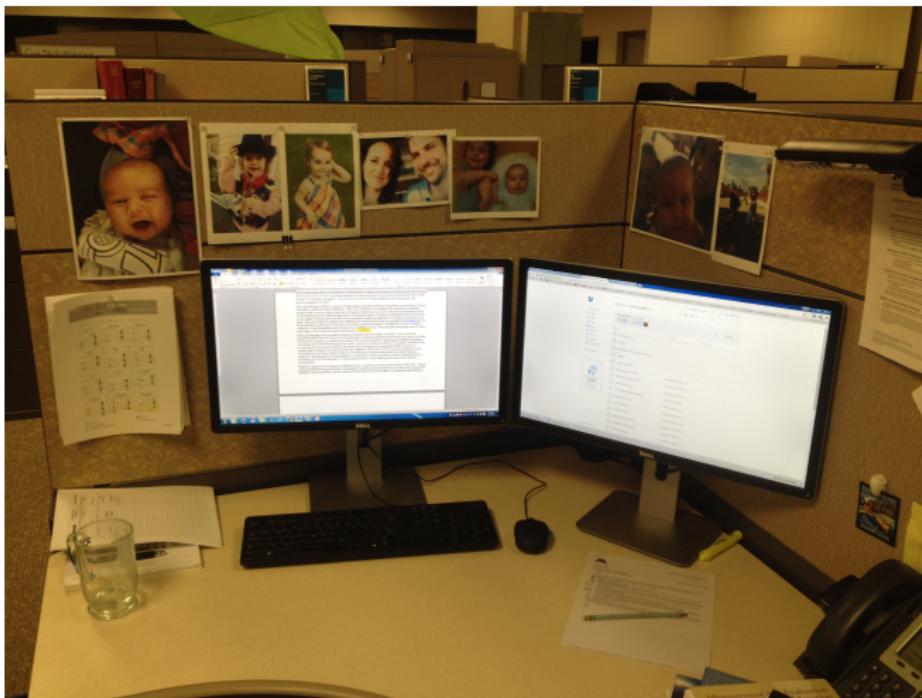


Figure 9: Where the magic happens . . .

Ecolab, Inc.



Figure 10: Image credit: Patrick Kennedy, Star Tribune²

- Started out at Ecolab working in R&D (+ Eng)
- Interned with a small team of staff statistical consultants
- Typical data for data-ing: Lots of design & analysis of experiments
- Assist teaching in-house statistics courses for Engineers, Mgmt, scientists, etc (Intro, DOE, MSA, SPC, RDSA)

²Kennedy, P., (6 Feb 2023). Ecolab now selling products at Home Depot — the first time available at retail stores. Star Tribune. URL:

[https://www.startribune.com/ecolab-now-selling-products-at-home-depot-the-](https://www.startribune.com/ecolab-now-selling-products-at-home-depot-the/)

Medtronic, PLC



Figure 11: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- World's largest medical technology company
- Hired due to commitment to government regulators!
- Data for Data-ing: verbatim complaints from call center, manufacturing lines, *some* clinical, sales & registration data, engineering diagnostics from in-house returned product analysis, lots more!

Medtronic, PLC



Figure 12: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- “What happens when a competent statistician gets released into a sea of engineers?”

Medtronic, PLC



Figure 12: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- “What happens when a competent statistician gets released into a sea of engineers?”
- “YOU GET BUSY!!” ~Tom Keenan (Matt’s MDT mentor)

Medtronic, PLC



Figure 12: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- “What happens when a competent statistician gets released into a sea of engineers?”
- “YOU GET BUSY!!” ~Tom Keenan (Matt’s MDT mentor)
- Promoted to Senior Statistician

Medtronic, PLC



Figure 12: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- “What happens when a competent statistician gets released into a sea of engineers?”
- “YOU GET BUSY!!” ~Tom Keenan (Matt’s MDT mentor)
- Promoted to Senior Statistician
- Broader involvement including Quality, Manufacturing, R&D, Marketing, HR/Personnel, Six Sigma

Medtronic, PLC



Figure 12: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- “What happens when a competent statistician gets released into a sea of engineers?”
- “YOU GET BUSY!!” ~Tom Keenan (Matt’s MDT mentor)
- Promoted to Senior Statistician
- Broader involvement including Quality, Manufacturing, R&D, Marketing, HR/Personnel, Six Sigma
- Regularly tasked with discussing/explaining statistical methodology and procedures to government regulators (e.g., post-market surveillance)

Medtronic, PLC



Figure 12: Medtronic Headquarters. image credit:
<https://asiapac.medtronic.com/xp-en/about.html>

- “What happens when a competent statistician gets released into a sea of engineers?”
- “YOU GET BUSY!!” ~Tom Keenan (Matt’s MDT mentor)
- Promoted to Senior Statistician
- Broader involvement including Quality, Manufacturing, R&D, Marketing, HR/Personnel, Six Sigma
- Regularly tasked with discussing/explaining statistical methodology and procedures to government regulators (e.g., post-market surveillance)
- Develop & teach in-house statistics courses (again!)

Nonin Medical. Inc



Figure 13: Nonin Pulse Oximeter. image credit: Michael Heisson³

- Senior Biostatistician (“only” statistician...)
- Internal & external collaborations (e.g., anesthesiology research, clinical trial design, etc)
- Data for Data-ing: all of it.

³Lee, E., (4 Oct 2022). The Best Pulse Oximeter for Home Use. New York Times Wirecutter. URL: <https://www.nytimes.com/wirecutter/reviews/best-pulse-oximeter-for-home-use/>

Back to Medtronic!?

- Back to Medtronic for a lame duck session
- Goals: clean up special projects, train new statisticians (& business analysts) and help automate my own job away (!)
- Next Stop: Penn State!



Figure 14: image credit: Penn State Office of Physical Plant

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background. . .

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background...
- Ever experience that look when someone seems to be calculating your age while you talk with them?

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background...
- Ever experience that look when someone seems to be calculating your age while you talk with them?
- When did you say you graduated?

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background...
- Ever experience that look when someone seems to be calculating your age while you talk with them?
- When did you say you graduated?
- How old did you say your kids are?

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background...
- Ever experience that look when someone seems to be calculating your age while you talk with them?
- When did you say you graduated?
- How old did you say your kids are?
- ... and you worked there how many years?

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background...
- Ever experience that look when someone seems to be calculating your age while you talk with them?
- When did you say you graduated?
- How old did you say your kids are?
- ... and you worked there how many years?
- [hmm... something isn't adding up]

Sidebar

- When I was a few years younger, people gave me puzzled looks when I described this background...
- Ever experience that look when someone seems to be calculating your age while you talk with them?
- When did you say you graduated?
- How old did you say your kids are?
- ... and you worked there how many years?
- [*hmm... something isn't adding up*]
- Life hack: I earned my PhD *while* working full-time (and child-rearing)

Personal reflections from industry

- I began to notice gaps between my expectations/assumptions for my contributions at work and the reality of my experiences on the job...
- *Expectation:* UMN Statistics Dept filled my toolbox with advanced methods & fancy models... that's what they'll expect me to do at work.
- *Mind the gap:* At work, I generally used 10-20% of the fancy things I learned in those courses

Personal reflections from industry

- I began to notice gaps between my expectations/assumptions for my contributions at work and the reality of my experiences on the job...
- *Expectation:* UMN Statistics Dept filled my toolbox with advanced methods & fancy models... that's what they'll expect me to do at work.
- *Mind the gap:* At work, I generally used 10-20% of the fancy things I learned in those courses
- Lots of the fancy methods that I needed at work, I *learned* at work. This is a common refrain among professional statisticians.

Personal reflections from industry

- *Mind the gap:* I noticed statisticians were regularly requested to engage with myriad issues that were **not at all statistical** in nature.

Personal reflections from industry

- *Mind the gap:* I noticed statisticians were regularly requested to engage with myriad issues that were **not at all statistical** in nature.
- **Bad** reason this gap might emerge: management may not understand how statisticians best contribute to the organization⁴

⁴Deming, W. E. (2000). *Out of the Crisis*. MIT Press.

Personal reflections from industry

- *Mind the gap:* I noticed statisticians were regularly requested to engage with myriad issues that were **not at all statistical** in nature.
- **Bad** reason this gap might emerge: management may not understand how statisticians best contribute to the organization⁴
- **Good** reason this gap might emerge: (coming up later...)

⁴Deming, W. E. (2000). *Out of the Crisis*. MIT Press.

Mind the Gap: An incomplete picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

June 25, 2023
Maleny, Australia

Mind the gap



Figure 15: image credit: <https://www.stuff.co.nz/travel/78997789/mind-the-gap-voice-of-london-tube-dies>

Mind the gap



Figure 16: Some gaps are bigger than others

Mind the gap

Search



GAPMINDER

Donate

Resources

About

Log in

You are probably wrong about



Natural
disaster
deaths



Global
hunger



Education
quality



Water at
home



Raw
materials



Domestic
work



We have tested thousands of people and they were systematically wrong about all this.

Upgrade your worldview

Gapminder is an independent educational non-profit fighting global misconceptions.

Figure 17: <https://www.gapminder.org/>

Mind the gap



- Role of statisticians at work
- Public perception of Statistics
- Student perception of EDA
- Opportunities for research

Mind the gap: statisticians at work

- Previously

As a statistical consultant, the first project with a first-time client is usually a disaster.

(Paraphrase of Sandy Weisberg)

Mind the gap: In the public

- *statistics vs Statistics*

Mind the gap: In the public

- *statistics vs Statistics*
- I meet students all the time that tell me they became interested in studying statistics by watching sports...

Mind the gap: In the public

- *statistics vs Statistics*
- I meet students all the time that tell me they became interested in studying statistics by watching sports...
- a “statistic” could be regarded as a collective property of some data (e.g., a quantity calculated from a sample)

Mind the gap: In the public

- *statistics vs Statistics*
- I meet students all the time that tell me they became interested in studying statistics by watching sports...
- a “statistic” could be regarded as a collective property of some data (e.g., a quantity calculated from a sample)
- Among the greatest contributions the field of Statistics offers the world is the means to appropriately accommodate, characterize, and even quantify **variability** and **uncertainty**

Mind the gap: EDA⁵

- Perceived value vs potential contribution of EDA

Mind the gap: EDA⁵

- Perceived value vs potential contribution of EDA
- even (maybe especially) among a group I'll call "advanced novices"

Mind the gap: EDA⁵

- Perceived value vs potential contribution of EDA
- even (maybe especially) among a group I'll call "advanced novices"
- temptation to rush into statistical modelling and skip ahead to "get the answers"

Mind the gap: EDA⁵

- Perceived value vs potential contribution of EDA
- even (maybe especially) among a group I'll call "advanced novices"
- temptation to rush into statistical modelling and skip ahead to "get the answers"
- EDA = summary statistics & cursory plots (to appease Professor)

⁵Exploratory Data Analysis

Mind the gap: EDA

- My solution?

Mind the gap: EDA

- My solution?
- maybe my students just need a framework for a careful EDA

Mind the gap: EDA

- My solution?
- maybe my students just need a framework for a careful EDA
- with an acronym to help remember it!

EDA Framework (1st attempt)

Get in “B-E-D” with your data

- Become acquainted with the data

EDA Framework (1st attempt)

Get in “B-E-D” with your data

- Become acquainted with the data
- Explore intuition for your research question(s)

EDA Framework (1st attempt)

Get in “B-E-D” with your data

- **B**ecome acquainted with the data
- **E**xplore intuition for your research question(s)
- **D**iscover features in the data that impact modeling decisions

EDA Framework (1st attempt)

Get in “B-E-D” with your data

- **B**ecome acquainted with the data
- **E**xplore intuition for your research question(s)
- **D**iscover features in the data that impact modeling decisions
- . . . not a great acronym

EDA Framework (2nd attempt)

Let's just reuse "E-D-A" instead!

- **Examine the data source(s):** data provenance, variable types, coding, missingness, summary statistics/plots;

EDA Framework (2nd attempt)

Let's just reuse "E-D-A" instead!

- **Examine the data source(s):** data provenance, variable types, coding, missingness, summary statistics/plots;
- **Discover features that influence may modeling decisions:** investigate potential outliers, consideration for recoding variables (e.g., numeric data that's functionally dichotomous), threats to modeling assumptions (*especially* independence);

EDA Framework (2nd attempt)

Let's just reuse "E-D-A" instead!

- **Examine the data source(s):** data provenance, variable types, coding, missingness, summary statistics/plots;
- **Discover features that influence may modeling decisions:** investigate potential outliers, consideration for recoding variables (e.g., numeric data that's functionally dichotomous), threats to modeling assumptions (*especially* independence);
- **Address research questions:** build intuition and note preliminary observations/conclusions related to each research question. Also, note observations that prompt you to refine your research questions or add new questions to investigate

EDA Framework (2nd attempt)

Let's just reuse "E-D-A" instead!

- **Examine the data source(s):** data provenance, variable types, coding, missingness, summary statistics/plots;
- **Discover features that influence may modeling decisions:** investigate potential outliers, consideration for recoding variables (e.g., numeric data that's functionally dichotomous), threats to modeling assumptions (*especially* independence);
- **Address research questions:** build intuition and note preliminary observations/conclusions related to each research question. Also, note observations that prompt you to refine your research questions or add new questions to investigate
- p.s. Lonneke's work included a concise summary of literature that I think improves upon the "E" step!

Mind the gap: Opportunity for research?

Mind the gap: Statistical Thinking

International Statistical Review (1999), 67, 3, 223–265, Printed in Mexico
© International Statistical Institute

Statistical Thinking in Empirical Enquiry

C.J. Wild and M. Pfannkuch

Department of Statistics, University of Auckland, Private Bag 92019, Auckland, New Zealand

This paper had its genesis in a clash of cultures. Chris Wild is a statistician. Like many other statisticians, he has made impassioned pleas for a wider view of statistics in which students learn “to think statistically” (Wild, 1994). Maxine Pfannkuch is a mathematics educator whose primary research interests are now in statistics education. Conception occurred when Maxine asked “What *is* statistical thinking?” It is not a question a statistician would ask. Statistical thinking is the touchstone at the core of the statistician’s art. But, after a few vague generalities, Chris was reduced to stuttering.⁶

Figure 18: Opening vignette from one of my favorite papers.⁶

⁶Wild, C. J., Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, 67(3), pp 223-265.

Thinking Statistically

- Recall: *Mind the gap*: Statisticians like me were regularly requested to engage with myriad issues at Medtronic that were **not at all statistical** in nature...

Thinking Statistically

- Recall: *Mind the gap*: Statisticians like me were regularly requested to engage with myriad issues at Medtronic that were **not at all statistical** in nature...
- *Bad reason*: management unclear what contribution statisticians offer to the organization

Thinking Statistically

- Recall: *Mind the gap*: Statisticians like me were regularly requested to engage with myriad issues at Medtronic that were **not at all statistical** in nature...
- *Bad reason*: management unclear what contribution statisticians offer to the organization
- **Good reason**: perhaps my colleagues recognized that we don't just "do statistics" we're experts at *thinking statistically!*

Thinking Statistically

- Recall: *Mind the gap*: Statisticians like me were regularly requested to engage with myriad issues at Medtronic that were **not at all statistical** in nature...
- *Bad reason*: management unclear what contribution statisticians offer to the organization
- **Good reason**: perhaps my colleagues recognized that we don't just "do statistics" we're experts at *thinking statistically*!
- I argue that *statistical thinking transfers*

Thinking Statistically

- Recall: *Mind the gap*: Statisticians like me were regularly requested to engage with myriad issues at Medtronic that were **not at all statistical** in nature...
- *Bad reason*: management unclear what contribution statisticians offer to the organization
- **Good reason**: perhaps my colleagues recognized that we don't just "do statistics" we're experts at *thinking statistically*!
- I argue that *statistical thinking transfers*
- Disciplined approach to problem solving & critical thinking

Thinking Statistically

- Recall: *Mind the gap*: Statisticians like me were regularly requested to engage with myriad issues at Medtronic that were **not at all statistical** in nature...
- *Bad reason*: management unclear what contribution statisticians offer to the organization
- **Good reason**: perhaps my colleagues recognized that we don't just "do statistics" we're experts at *thinking statistically*!
- I argue that *statistical thinking transfers*
- Disciplined approach to problem solving & critical thinking
- Due consideration for uncertainty, alternative explanations, and practical implications

Mind the gap: Data & Data-ing

"the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept."

- So, why verb the noun??

Mind the gap: Data & Data-ing

"the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept."

- So, why verb the noun??
- Maybe because a verb for the action we're describing *doesn't exist!*

What *IS* data-ing?

- Something new to be explored?

What *IS* data-ing?

- Something new to be explored?
- Something familiar by another name?

What *IS* data-ing?

- Something new to be explored?
- Something familiar by another name?
- An intersection?

What *IS* data-ing?

- Something new to be explored?
- Something familiar by another name?
- An intersection?
- A superset?

What actions might data-ing include?

- data collection (Yannik & Susanne)
- variable creation/recognition (Amelia & Sibel)
- data cleaning (Many SRTL-ers)
- modeling and interpretation of data (Lucia)

More engaging and reasoning with data

- Andee & Michal probe evaluation of which data **needed** to achieve the scientific purposes?
- Carl & Kym evoke notions about data and empowering students to uncover rich (multivariate) stories
- Alyssa seeks to examine the interface between computational thinking and data-ing
- What if we favor an algorithmic rather than inferential “culture”?⁷
- Ronit challenges us to consider “big data-ing”

More engaging and reasoning with data

- Andee & Michal probe evaluation of which data **needed** to achieve the scientific purposes?
- Proxy variables when we encounter a gap in the available (or accessible) data to achieve the scientific purpose of our analysis—really important part of “data-ing” as an applied statistician, but these are motivated by the scientific domain
- Carl & Kym evoke notions about data and empowering students to uncover rich (multivariate) stories
- Alyssa seeks to examine the interface between computational thinking and data-ing
- What if we favor an algorithmic rather than inferential “culture”?⁷
- Ronit challenges us to consider “big data-ing”

⁷Breiman, L. (2001). Statistical modeling: The two cultures. *Statistical science*, 16(3), 199-231.

How well-defined is “data”

- Is “messy” data well-defined?
 - any deviation from tidy data⁸?
 - Amelia & Kym discuss intuition of data cards
- What is “big data”?⁹
 - Volume? Velocity? Variety?¹⁰
 - Does “messier” make it “bigger”
 - Is the distinction absolute or relative?
 - how will this make “big data-ing” different?
- Jill & Lonneke discuss consuming and evaluating evidence—and implications of data-ing when engaged with forms of evidence more broadly conceived than has been typical for classical data analysis

⁸Wickham, H. (2014). Tidy data. *Journal of Statistical Software*, 59(10). DOI: 10.18637/jss.v059.i10

⁹Kitchin, R., & McArdle, G. (2016). What makes Big Data, Big Data? Exploring the ontological characteristics of 26 datasets. *Big Data & Society*, 3(1).

¹⁰Laney, D. (2001). 3D data management: Controlling data volume, velocity and variety. In: Meta Group.

- I'm struck by the parallel to the vignette about Statistical thinking...

- I'm struck by the parallel to the vignette about Statistical thinking...
- The idea of data-ing seems to have been right in front of us all along,

- I'm struck by the parallel to the vignette about Statistical thinking...
- The idea of data-ing seems to have been right in front of us all along,
- it's something we value,

- I'm struck by the parallel to the vignette about Statistical thinking...
- The idea of data-ing seems to have been right in front of us all along,
- it's something we value,
- and want our students to value,

- I'm struck by the parallel to the vignette about Statistical thinking...
- The idea of data-ing seems to have been right in front of us all along,
- it's something we value,
- and want our students to value,
- and yet we don't even know what to call it!!

- I'm struck by the parallel to the vignette about Statistical thinking...
- The idea of data-ing seems to have been right in front of us all along,
- it's something we value,
- and want our students to value,
- and yet we don't even know what to call it!!
- What might we learn as we refine our view of data-ing together?

- I'm struck by the parallel to the vignette about Statistical thinking...
- The idea of data-ing seems to have been right in front of us all along,
- it's something we value,
- and want our students to value,
- and yet we don't even know what to call it!!
- What might we learn as we refine our view of data-ing together?
- In what ways might we reconceptualize data?

“How does one speak about something that is both fish and water, means as well as end?” – Ursula Franklin¹¹

- epigraph of Jer Thorp's “Living in Data”...

¹¹Franklin, U. (1990). *The Real World of Technology*. CBC Enterprises: Toronto

“How does one speak about something that is both fish and water, means as well as end?” – Ursula Franklin¹¹

- epigraph of Jer Thorp's “Living in Data”...
- and perhaps SRTL-13 as well??

¹¹Franklin, U. (1990). *The Real World of Technology*. CBC Enterprises: Toronto

References

- Batty, M. (2015). Data about cities: Redefining big, recasting small. Paper prepared for the Data and the City workshop, Maynooth University, 31 August–1 September 2015. URL: <http://www.spatialcomplexity.info/files/2015/08/Data-Cities-Maynooth-Paper-BATTY.pdf>
- Breiman, L. (2001). Statistical modeling: The two cultures. *Statistical science*, 16(3), 199-231.
- Deming, W. E. (2000). *Out of the Crisis*. MIT Press.
- Kitchin, R., & McArdle, G. (2016). What makes Big Data, Big Data? Exploring the ontological characteristics of 26 datasets. *Big Data & Society*, 3(1).
- Laney, D. (2001) 3D data management: Controlling data volume, velocity and variety. In: Meta Group. URL: <https://studylib.net/doc/8647594/3d-data-management--controlling-data-volume--velocity--an...>
- Tukey, J. (1977). *Exploratory Data Analysis*. Vol 2.
- Wickham, H. (2014). Tidy data. *Journal of Statistical Software*, 59(10). DOI: 10.18637/jss.v059.i10
- Wild, C. J., Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, 67(3), pp 223-265.

Mind the Gap: An incomplete picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

June 25, 2023
Maleny, Australia