Statistical Literacy Goes Beyond Quantitative Literacy

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Slides and paper:
www.StatLit.org/pdf /2022-Mathfest-Slides.pdf
www.StatLit.org/pdf /2022-Schield-Mathfest.pdf

Quantitative Reasoning/Literacy is a subset of Mathematics

QR/QL topics: numbers and quantities, percent of and % change, measurement and indices, linear and exponential growth, graphs and discrete math. (Madison et al, 2012).

QR/QL focuses on mathematical associations:

- Converting counts to ratios can change the size and direction of an association of counts.
- regression (standardization) can change the size and direction of an association of ratios.

Statistical Literacy goes beyond Quantitative Reasoning/Literacy

Six differences:

1. Induction vs. deduction
2. Statistics vs. numbers (matter vs. form)
3. Causation vs. association
4. Confounder vs. covariate (mediator, mechanism)
5. Strength of evidence vs. truth of evidence
6. Experiments (doing) vs. observational (seeing)

1. Induction vs. Deduction

Mathematics is deductive.
Deduction gives mathematics its power!
Quantitative Literacy is a subset of mathematics.

Statistical Literacy is a subset of statistics.
Statistics uses -- but goes beyond -- mathematics.
Statistics is both deductive and inductive.

Arguing about a generalization, a prediction, a specification or a cause is inductive.

Induction vs. Deduction (cont.)

Most claims in the everyday media involve statistics. Most of the supporting arguments are inductive.

If students are to be able to think critically about statistics as evidence in arguments, they need to deal with inductive reasoning:

- Strength of evidence offered by the statistics
- Resilience of the statistics to being influenced

2. Statistics vs. Numbers

Statistics are numbers in context where the context matters.

In math, 1 + 1 = 2. The units are "things".

- In 'bunny math', 1 + 1 can be more than 2.
- In 'ice-cube math', 1 + 1 can be less than 2.

The context may determine the size of a statistic and the direction of an association between two statistics.

3. Causation vs. Association

There is no mathematical operator for 'causation'.

In Physics, Force = Mass * Acceleration
In Math, these three symbols are just variables.

Co-variation: "As X increases, Y increases"
These changes (X increases) are not internal.
They are a change in focus from X1 to X2.
As weight increases by 5#, height increases by 1".

4. Confounder vs. Covariate

Covariate: anything that varies with something else.

Association: Lightning and thunder are correlated.
"*Heated air*" is a co-variate – not a confounder.
Some covariates are mechanisms or mediators:
the means by which lightning causes thunder.

You need causation to identify a confounder.

Moral: adjust only for confounders
Do not adjust for mechanisms or mediators.

5. Strength of Evidence vs. Truth of Evidence

In deduction, true premises and a valid argument guarantee the truth of the conclusion.

In induction, the strength of evidence is critical.

An association is stronger, the more confounder resistant it is. Confounder resistance increases:

- the larger the effect size.
- the more factors taken into account (controlled for)
- the more appropriate the factors: the denominators

6. Experiments versus Observational studies

Experiments resist confounders more than studies.

An experiment involves a *doing* by a researcher or by nature. A *doing* is a change in reality. The researcher 'sees' what happens to the subjects.

In an observational study, the researcher just 'sees'. Any researcher-doing is directed by the subjects.

Doing (causation) is not a mathematical concept.

QR/QL cannot distinguish these two w/o causality.

Conclusion #1

Mathematics is limited to associations.
Other disciplines study association and causation.
They want to understand how and why things happen

Statistical literacy (S/L) involves causation.
Statistical Literacy enables students to think critically about statistics found in everyday life.

Statistical literacy goes beyond quantitative literacy because statistics goes beyond mathematics.

Conclusion #2

Numeracy is often described as synonymous with quantitative literacy or quantitative reasoning.

Yet numeracy is sometimes described as "reasoning with data in everyday life".

To "deal with data in everyday life", numeracy must expand quantitative literacy.

Numeracy must include statistical literacy so Numeracy can be a tool for all situations.

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