Math 161

Glen Pugh

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1. Chapter 8: Measuring

2. Chapter 9: Do the Numbers Make Sense?

Chapter 8: Measuring

The Basics

Gathering data by counting things is a form of measurement, but measurement can be a bit more complicated.

- Measurement: the assignment of a number to a variable describing a characteristic of a person or thing. Measurements should state the units used (cm, kg, days, etc).
- Example: Student performance on a test: 43 %.
- Example: Milk production of cows on farmer Brown's dairy farm. Measurement: 30 L/day.

Not so Easy: What Exactly Are You Trying to Measure?

- Must attempt to be as clear as possible about
  - how variables used to describe property are defined,
  - whether the values assigned to variables are valid measures of the property of interest,
  - whether the measurements are accurate.
- Example: 2005: CNN declares Vancouver as world's most liveable city. The Economist Intelligence Unit's LIVEABILITY RANKING, part of the Worldwide Cost of Living Survey, assesses living conditions in 127 cities around the world by looking at nearly 40 individual indicators grouped into five categories: stability; healthcare; culture and environment; education; and infrastructure. The survey gives a rating of 0%-100% and judges a city with a lower score to be the more attractive destination. A rating of 20% is where real problems are seen to begin - anything over 50% places severe restrictions on lifestyle.

What's the Best Way to Measure?

- Valid Measure (of a property): relevant or appropriate as a representation of that property.
- Example (easy): Weight of a car leaving factory. Typical measure: Curb weight in kg: Weight of car (including full tank of gas, all oil, etc) without passengers.
- Example (not so easy): Intelligence. Typical measure: IQ (Intelligence Quotient) Standardized test which ranks individuals in population. Valid?

What's the Best Way to Measure? (cont'd)

- Example: Knowledge and academic ability/achievement: grades (%)
  Srinivasa Ramanujan: thought by some to be one of the greatest mathematicians of all time. Self taught, died in 1920 at age 32. Failed his non-mathematical courses at college.
- Example: Knowledge and academic ability/achievement: grades (%)
  Albert Einstein: failed entrance exams for engineering school in Switzerland.
- One might argue that, as a measure of knowledge and academic ability/achievement, school grades suffer from poor predictive validity: the ability to predict success in areas related to the property being measured.

What's the Best Way to Measure? (cont'd)

- Rate vs. Counts: Often more informative (and appropriate) to determine the rate at which something occurs rather than the simple count of the number of occurrences.
- Example: Homicide in Western Countries: which is the safer country: Scotland or Canada? (using a measure based on number of homicides, data from year 2000),
  - Scotland had 104 homicides, Canada 546.
  - But, total populations: Scotland 5,062,900, Canada 30,689,035
  - So homicide rates per 100,000 citizens: Scotland 2.05, Canada 1.78
- Example: Unemployment Rate (percentage of labour force actively seeking work): 6.0% as of Fri Sep 7 2007.

Accuracy of Measurements

So far, emphasis on
- What it is that we are trying to measure
- How best to measure it

Also crucial: Measuring accurately!

The Anatomy of a Measurement

- Breaking a measurement up into component parts:

  measured value = true value + bias + random error

- Example: Repeatedly measure length of pencil to nearest tenth of a centimeter using the same ruler.
- The pencil hasn't changed, but measurements are different:
  - First cm marked on ruler is a little short, which introduces bias into our measurement: systematic understatement or overstatement of the true measure
  - Some variation in repeated estimates of tenths of a cm: random error. If random error is small, measurement technique is said to be reliable.

Averaging to Improve Accuracy

- If possible, to improve accuracy, repeat a measurement several times and take the average
- Principle: random error associated to a particular measurement has an average value of zero (over the long run), so the average error from a number of repeated measurements should be close to zero.
- Taking averages does nothing to combat bias.

Chapter 9: Do the Numbers Make Sense?

View Reported Data with a Critical Eye

Even if data has been gathered through very accurate measurement, we should still worry about where it came from, who gathered it, who is sponsoring the study, is there perhaps a hidden agenda behind the study, etc.

- Are we getting the whole story?
- Publication Bias: the tendency for research with favourable findings to be published, for example research supporting a hypothesis or a new drug, while the research with unfavourable findings is not reported.
- "More than two-thirds of studies of anti-depressants given to depressed children, for instance, found the medications were no better than sugar pills, but companies published only the positive trials." (Sydney Morning Herald, Sep 2004)

Combating Publication Bias

- Example: Paper "Pharmaceutical industry sponsorship and research outcome and quality: systematic review" by Lexchin, Bero, Djulbegovic, Clark (BMJ 2003):
  Findings: "30 studies were included. Research funded by drug companies was less likely to be published than research funded by other sources. Studies sponsored by pharmaceutical companies were more likely to have outcomes favouring the sponsor than were studies with other sponsors. . . None of the 13 studies that analysed methods reported that studies funded by industry was of poorer quality."
- 2001: The International Committee of Medical Journal Editors (participating journals include The New England Journal of Medicine, The Lancet) declared that for studies sponsored in their journals, the study "sponsor must impose no impediment, direct or indirect, on the publication of the study's full results, including data perceived to be detrimental to the product."

Do the Numbers Add Up?

- Are results consistent?
- "Three-fourths of Chapel Hill residents are satisfied with the town's parks and recreation programs, according to a survey conducted by the Chapel Hill Parks and Recreation Commission. Of 258 persons who answered the survey, 96 percent were white. Thirty-eight percent of the 10 non-whites surveyed said they were satisfied with recreation services; 73 percent indicated they used the parks." (Durham (North Carolina) Morning Herald, February 23, 1982.)

Implausible Numbers

- Do the numbers make sense?
- "Battling Hunger, a food pantry, said it delivered 110,000 tons of food to Detroit last Thanksgiving. The food was delivered to help residents there overcome the effects of a severe economic slump, particularly in the automobile industry." (Wall Street Journal, January 2006)
- Population of Detroit is about one million, so that's about 220 pounds of food per person!

Do the Math. . .

- Is the math right?
- Computer maker Packard Bell had sales of $20 billion dollars over ten years and $45 million in profits, a profit margin of 2% of sales. (Forbes magazine, April 1996)