Displaying Visual Evidence in Scientific Research:

Help viewers make valid scientific decisions

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Our CLIMB curriculum of workshops on communication in scientific research

1) Delivering scientific presentations and posters for impact: 
   *Make it stick with SUCCESSs*

2) Crafting the introduction to a scientific presentation: 
   *Create a mystery box*

3) Communicating and collaborating across disciplines: 
   *Use simple words*

4) Displaying visual evidence in scientific presentations: 
   *Help viewers make valid scientific decisions*
Let’s consider 2 case studies from Tufte’s *Visual Explanations*

Effective displays help lead to valid arguments and true conclusions.

Ineffective displays often lead to invalid arguments and false conclusions.

**Garbage In - Garbage Out**
Case 1: Dr John Snow intervenes in a cholera epidemic

Context
- Cholera breaks out in London in 1854
- Cholera: rapid dehydration (diarrhea, vomiting) and death
- Fatality rate: 50%
- Killed millions in other epidemics

Problems
- Deficiencies in:
  - Understanding of bacteria
  - Technology
  - Sanitary living conditions

Questions
- How is cholera transmitted?
- How can we stop this cholera epidemic?

Hypotheses
Cholera is spread by:
1. Breathing vapors of decaying matter
2. Drinking contaminated water
Dr John Snow investigated the cholera epidemic

Consider the data
- Are locations of water sources and deaths significant?
- He obtained death certificates and created a visual map.

Communicate and convince
- He reported his findings to the local authorities
- He had to convince them that a specific water source was contaminated, and caused cholera

Conclusions
- Handle on the Broad Street water pump was removed
- Epidemic soon ended

Snow’s visual evidence helped to make valid scientific decisions.
Is your visual display helping or hindering valid scientific decisions?

Mark Monmonier’s *How to Lie with Maps*
aggregates of Snow’s map:

Gregory Joseph’s *Modern Visual Evidence*
quarterly data

fiscal years

calendar years
Case 2: Decision to Launch the Space Shuttle Challenger in January 1986

Context
● O-rings seal segments of the booster rockets.
● Previous launches showed damage to the O-rings.

Problems
● All past launches occurred at temperatures of >53 °F.
● Forecasted temperature of the launch was 26-29 °F.

Questions
● Will the O-rings maintain their seal at 26-29 °F?
● Should the launch proceed?

Hypotheses
● Engineers: No, and then Yes
● NASA officials: Yes
Engineers at Morton Thiokol Inc (MTI) initially argued against the launch

- MTI faxed 13 slides to NASA
- Slide 1 of 13

Blow-by = soot and gases blowing by O-ring seals

SRM = solid rocket motor

What’s missing here?
Engineers at Morton Thiokol Inc (MTI) initially argued against the launch

- Slide 2 of 13

<table>
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<th>AMB</th>
<th>O-RING</th>
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<td>26</td>
<td>29</td>
<td>10 mph</td>
</tr>
</tbody>
</table>

What’s missing here?
MTI initially argued against the launch

- MTI faxed 13 slides to NASA

Recommen dations:

- O-ring temp must be $\geq 53^\circ F$ at launch
- Development motors at 47° to 52°F with putty packing had no blow-by
- SRM 15 (the best simulation) worked at 53°F
- Project ambient conditions (temp & wind) to determine launch time

- How would you respond to this argument? Was this effective?
- This was MTI’s only no-launch recommendation in 12 years.
- A NASA official responded that he was “appalled” by MTI’s recommendation not to launch, and asked them to reconsider.
NASA officials asked MTI to reconsider, and MTI reversed their decision.

After 1 minute from launch, the space shuttle Challenger exploded and 7 astronauts died.
Post-Analysis: MTI’s original conclusion was true, but with an ineffective argument.

- Commission investigating the accident:
  “A careful analysis of the flight history of O-ring performance would have revealed the correlation of O-ring damage and low temperature. Neither NASA nor Thiokol carried out such an analysis; consequently, they were unprepared to properly evaluate the risks of launching the 51-L [Challenger] mission in conditions more extreme than they had encountered before.”

- How might the data have been better analyzed, presented and communicated?
Let’s evaluate MTI’s 2nd attempt in visual displays after the accident

- See the handout
- What are the pro’s and con’s of this data display?
- What can be done to help viewers make a valid scientific decision?
Tufte’s revision summarizes all data into a graph with a “Damage Index”

Tufte’s visual display would have helped viewers make a valid scientific decision.
Take-Home Lessons from Two Case Studies

● Case 1: John Snow intervened in a cholera epidemic
  ○ He summarized all relevant info in a simple map
  ○ **He helped viewers make a valid scientific decision**

● Case 2: Decision to launch the space shuttle
  ○ MTI had all info, but created an ineffective data display, even after the accident
  ○ Tufte’s revision summarized all relevant info in a simple graph
  ○ **Tufte helped viewers make a valid scientific decision**