# Concepts for building an understanding of uncertainty

Rebecca F. Lippmann
University of Maryland

Supported in part by NSF grant REC-008 7519

## Teaching Uncertainty

- Motivation
- Previous Research
- Examples of Student Reasoning
- Measurement Concepts
- Suggestions



## Why Uncertainty?

Prepare bioscience majors and pre-**health-care** professionals for future careers.

bioscience

You measured a person's blood pressure to be 150/90.
Should you give the person medication?

You measured a moth's antennae.
Is it a member of a known species or an unknown species?

Was the process for cloning insert DNA into a certain vector successful?



## Previous Research

Set and point paradigms

A. Buffler, S. Allie. (2001). The development of first year physics students' ideas about measurement in terms of point and set paradigms, *Int. J. Sci. Educ., 23*(11), 1137-1156.

| Point | Set |
|---|---|
| One measurement is the true value | Distribution around true value |
| – use repeated value | – overlapping ranges |
| – use average | – use average plus uncertainty |



## Point Example

Which battery lasts longer, Energizer or Duracell?
A student performs an experiment measuring the number of hours two AA batteries from each brand will run a tape player. Her data is below.

| | Trial 1: | Trial 2: | Trial 3: | Trial 4: | Trial 5: | Average: |
|---|---|---|---|---|---|---|
| Duracell (hours) | 11.4 | 12.2 | 7.8 | 5.3 | 10.3 | 9.4 |
| Energizer (hours) | 11.6 | 7.0 | 10.6 | 11.9 | 9.0 | 10.0 |

**Point:** The Energizer battery lasts longer because, from the 5 trials, it had a longer average of hours lasted.



## Set Example

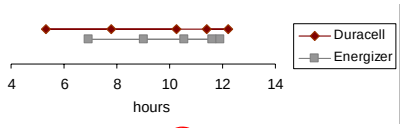
Which battery lasts longer, Energizer or Duracell?
A student performs an experiment measuring the number of hours two AA batteries from each brand will run a tape player. Her data is below.

| | Trial 1: | Trial 2: | Trial 3: | Trial 4: | Trial 5: | Average: |
|---|---|---|---|---|---|---|
| Duracell (hours) | 11.4 | 12.2 | 7.8 | 5.3 | 10.3 | 9.4 |
| Energizer (hours) | 11.6 | 7.0 | 10.6 | 11.9 | 9.0 | 10.0 |

**Set:** The information shows there is significant overlap so we cannot really tell which battery lasts longer. They last the same approximately.

## Measurement Concepts

Which battery lasts longer, Energizer or Duracell?
A student performs an experiment measuring the number of hours two AA batteries from each brand will run a tape player.




"We cannot really tell which battery lasts longer"

=

"They last the same approximately"

AAPT Austin Winter 2003 7

Cause of Range

"We cannot really tell which battery lasts longer"

Measurement method

Power consumption changed – volume, type of music, ff/rw

**External Variation**

"They last the same approximately"

Battery

Manufacturing quality control, storage, age

**Internal Variation**

AAPT Austin Winter 2003 8

## Measurement Concepts

Which battery lasts longer, Energizer or Duracell?
A student performs an experiment measuring the number of hours two AA batteries from each brand will run a tape player.

1 I would say Energizer because 3 out 5 trials, it lasted for longer hours than Duracell. Also, the average shows it lasting longer by .6hrs.

2 Although on average for the above trials, energizer appears to last longer, it cannot be concluded that this is the case for most or all situations because in 2/5 trials duracell was longer + 3/5 energizer was longer.

AAPT Austin Winter 2003 9

## Measurement Concepts

Which battery lasts longer, Energizer or Duracell?

Energizer won in 3 out of 5 trials

Which specific battery lasted longer?

**Descriptive Question**

It cannot be concluded which battery will win for most or all situations

Which brand will last longer?

**Predictive Question**

AAPT Austin Winter 2003 10

## Summary

**Descriptive Question**

"Did this battery outlast that battery?"

Point reasoning

**Predictive Question**

"Will one brand of battery last longer?"

Set reasoning

**External Variation**

Undesirable

Can be minimized

**Internal Variation**

Neutral

Part of investigation

AAPT Austin Winter 2003 11

## Modified Laboratory

Learning How to Learn Science:
Physics for bioscience majors

Develop learning environments to help foster meta-learning

Scientific community laboratory:

Progression of questions designed to develop an understanding of measurement and uncertainty

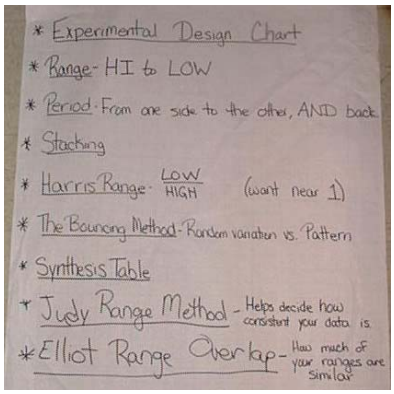
AAPT Austin Winter 2003 12

## Modified Laboratory

Build a scientific community

- Ask questions without 'known' answers (method and results)
- Focus on evaluation of lab for grading, allow experimentation
- Require students to defend their own results and question other group's results
- Let each section define tools and terms






## Example

You are designing a new booth for a traveling carnival. People will use a catapult to toss a penny onto a plate to win a prize.

If no one ever wins a prize, people will stop playing. If too many people win a prize, you will lose money.

So you want to make your plate large enough to catch a small fraction of pennies, but not large enough to catch them all.



## Terms

Intrinsic factor: internal, uncontrollable factors built into what you are measuring

Internal variability: you won't get the same result each trial even if everything you do is the same

Extraneous variables: outside things that affect what we're trying to measure (we want to keep constant)



## Conclusion

Measurement Concepts

- Affect student reasoning
- Are often overlooked

Help students separate ideas

- Ask questions that elicit ideas
- Let group define terms