Concepts for building an understanding of uncertainty

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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.

- 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

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.

<table>
<thead>
<tr>
<th>Trial 3</th>
<th>Trial 4</th>
<th>Trial 5</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energizer</td>
<td>11.4</td>
<td>12.2</td>
<td>7.8</td>
</tr>
<tr>
<td>Duracell</td>
<td>11.6</td>
<td>7.0</td>
<td>10.6</td>
</tr>
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Point: The Energizer battery lasts longer because it had a longer average of hours lasted.

Set Example
Which battery lasts longer, Energizer or Duracell?
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Set: The Energizer battery may have a small range of variation, while Duracell battery has a larger range of variation. They both perform 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"

Energizer won in 3 out of 5 trials
Which specific battery lasted longer?
It cannot be concluded which battery will win for most or all situations
Which brand will last longer?

Predictive Question
Descriptive Question

Power consumption changed—volume, type of music, ff/rw
Battery Manufacturing quality control, storage, age

External Variation
Internal Variation

Descriptive Question
Predictive Question
“Did this battery outlast that battery?”
“Will one brand of battery last longer?”
Point reasoning
Set reasoning

External Variation
Internal Variation
Undesirable
Neutral
Can be minimized
Part of investigation

Summary

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
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
Help students separate ideas
• Ask questions that elicit ideas
• Let group define terms