Integrating Research Methods into AP Statistics Through a Sustainable Energy Context

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The Challenge

- Entering college, students have weak foundations for empirical research\(^1\)

- AP Exam results:
  - Highest scores on data exploration, sampling
  - Lowest scores on investigative task, statistical inference
  - Struggles with application to problem contexts

<table>
<thead>
<tr>
<th>AP Exam (2013)(^2)</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics</td>
<td>12.60%</td>
<td>20.20%</td>
<td>25%</td>
<td>18.80%</td>
<td>23.4%</td>
<td>2.80</td>
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\(^1\) (Aguado, 2010)
\(^2\) totalregistration.net
Focus Questions

• How can we promote student’s abilities to problem solve and relate content to context?

• How might we increase student’s retention of statistical concepts and help them see “the big picture” of why statistics are important?

• What is a method we can integrate all of this into the standard curriculum to enrich students’ conceptual understanding?
Recommendations from GAISE

- Guidelines for Assessment and Instruction in Statistics Education
  - Emphasize statistical literacy & statistical thinking
  - Use real data
  - Stress conceptual understanding rather than procedural knowledge
  - Foster active learning in the classroom

(Garfield & Everson, 2009)
Why Research Methods in High School?

• D.school engineering design process:
  - Empathy, Define, Ideate, Prototype, Test
• Multidisciplinary approach to mathematics
  - Energy, sustainability, social sciences
• Lack of exposure to research projects/methods in science and especially math classes (literature review, etc.)
• Opportunity to explore interests in higher studies or future careers
Why the Integrated Approach?

• Potential benefits of a yearlong research design vs. a final research project:
  ☐ Benefits to student schedule, stress load
  ☐ Scaffolding through active practice
  ☐ Continual application to self-defined problem
  ☐ Increased retention beyond the classroom

• Examples of additional skills enriched:
  ▪ Communication & presentation skills
  ▪ Collaboration skills
  ▪ Scientific literature review, etc.
Standards

- AP Statistics Exam Topics
- Research method objectives
- STEM 4 Standards - Initiation & completion of original project design, study & presentation
  - CLE 4.1.1 – move flexibly between problem identification strategies, solution generation, communication skills and technical representation of solutions.
  - CLE 4.1.2 – independently examine and systematically analyze the dynamic structure of STEM based problems.
  - CLE 4.1.3 – apply learned design strategies to critically reason through existing STEM scenarios and identify potential conflicts and future needs.
## Integrated Research Design Framework

<table>
<thead>
<tr>
<th>UNIT</th>
<th>MAJOR UNIT TOPIC</th>
<th>RESEARCH METHODS*</th>
<th>PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td><strong>Exploring Data - Describing patterns and departures from patterns:</strong> Constructing/interpreting graphs of distributions of univariate data, summarizing and comparing distributions of univariate data, exploring bivariate data, exploring categorical data</td>
<td><strong>Empathize &amp; Define:</strong> Identifying topic of interest, conducting the literature review, building background information, identifying reputable sources, appropriate citation guidelines</td>
<td>Project proposal and Descriptive Essay about research topic</td>
</tr>
<tr>
<td>II.</td>
<td><strong>Sampling and Experimentation - Planning and conducting a study:</strong> Overview of methods of data collection, planning and conducting surveys vs. experiments, generalizability of results and types of conclusions that can be drawn from observational studies, experiments and surveys</td>
<td><strong>Ideate &amp; Prototype:</strong> Generating good research questions and hypotheses; identifying conditions, assumptions, and limitations; data gathering; preliminary descriptive data analysis</td>
<td>Methodology, Preliminary Descriptive Analysis of Data</td>
</tr>
<tr>
<td>III.</td>
<td><strong>Anticipating Patterns - Exploring random phenomena through probability:</strong> Probability, combining independent random variables, the normal distribution, sampling distributions, simulations of random phenomena</td>
<td><strong>Test &amp; Evaluate:</strong> Determining experimental validity, recognizing trends in data, statistical analysis and inference, drawing conclusions, identifying error and limitations, preparation of findings for presentation</td>
<td>Progress report, Statistical Analysis and Inference on Data</td>
</tr>
<tr>
<td>IV.</td>
<td><strong>Statistical Inference: Estimating population parameters and testing hypotheses:</strong> estimation (point estimators and confidence intervals), tests of significance</td>
<td><strong>Analysis &amp; Reflection:</strong> Statistical analysis and inference, drawing conclusions, identifying error and limitations, drawing implications and future prospects, preparation of findings for presentation</td>
<td>Poster and presentation</td>
</tr>
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Example Progression

**Unit 1:** Consumers tend to exhibit greater energy consuming behaviors during summer and winter seasons, therefore paying greater electricity bills. **WHY?**

- Maybe consumers set their thermostats to lower temps during summer, higher temps during winter (greater heating/cooling use) – could curtailment behavior reduce energy consumption?
- $H_0$: There is no difference between electricity bills paid by consumers who engage in curtailment behaviors and those who do not.
- $H_a$: There is a difference between the electricity bills paid by the two groups.
Example Progression Cont.

• **Unit 2:** Conduct survey to gather data on a range of consumer thermostat temperatures during summer and winter months, OR examine consumer willingness to engage in curtailment behaviors

  - Opportunity for advanced research topics, i.e.: message framing, influence of demographics

• **Unit 3:** Validation of experiment, data, practice in troubleshooting and identifying limitations

• **Unit 4:** Statistical analysis on data findings and draw into context of hypotheses
Implementation & Assessments

• Project topic proposal early Fall semester
• To provide:
  - Broad, general topics per group
  - Provide citations, background readings, additional resources (i.e.: practice data sets)
  - Allotted time per class/week for collaboration
• From Students:
  - Pre, Mid, and Post-Surveys to follow up on students’ progress, feedback for adjustments and assessment of integrated design efficacy
Implications for Learning

• Tying it all back to the Focus Questions, the Integrated Research Design hopes to:
  - Promote student’s abilities to problem solve and relate content to context
  - Increase student retention of statistical concepts and help them see “the big picture” of why statistics are important
  - Apply the above goals into the standard curriculum to enrich students’ conceptual understanding
References & Acknowledgements

• Instructional Guidelines - GAISE; amstat.org

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Questions?