Implementing PER-based Tutorials in the Second-semester Algebra-based Lecture-supported Mini-studio

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Talk Outline

- Briefly describe Lecture-supported Mini-studio
- Highlight success of Mini-studio in first-semester physics.
  - Use Jackie’s plot from her PERC poster to show this.
- Describe the worksheet materials used for second-semester classes.
- Discuss how we faced major pushback and were very surprised.
  - Faculty claims of treating students like guinea pigs, worksheet giving misconceptions, etc.
- We were thus limited to one section with Mini-studio set-up.
  - But we have 4 sections to compare with constant lecture instructor.
- Further surprised by CSEM results.
  - Highlight incentive and class attitude effects.
- For later implementations, we are moving to a TA-run mini-studio.
  - More cohesion between worksheet and lab time.
  - Expose future faculty to more research based curricula.
Review of Lecture-Supported Mini-Studio Format:

- Restructure existing ~3 classroom hours for recitation + lab.
- ~32 students work in 8 groups of ~4 people.

75 minutes: Conceptual / math skills worksheet & problem-solving; *Instructor led.*

15 minutes: *Quiz*

75 minutes: Laboratory Experiment; *GTA led.*
Mini-studio/Full-studio vs. Traditional Lecture: First-semester Physics

- Previous implementation of Lecture-Supported Mini-Studio\(^1\):
  - Mini-studio courses resulted in higher FCI post-test scores compared to both the Small and Large Traditional lecture courses.
  - Mini- and Full-studio produced similar post-test scores.

\(^1\)Chini and Rahman (2013). **Normalized gain averaged per student**
Mini-studio/Full-studio vs. Traditional Lecture: First-semester Physics

- Previous implementation of Lecture-Supported Mini-Studio:
  - $G = \frac{I_{\text{pre} \rightarrow C_{\text{post}}}}{I_{\text{pre}}}$; $L = \frac{C_{\text{pre} \rightarrow I_{\text{post}}}}{C_{\text{Pre}}}$
  - Generally higher gain ($G$), lower loss ($L$) in Mini-Studio compared to Traditional, and even Studio.\(^2\)

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\(^1\)Lasry, Guillemette, Mazur (2014), \(^2\)Chini and Pond (2014).
Mini-studio in Second-semester, Algebra-based Physics

- **Goal**: Integrate the Mini-studio into lab portions of second-semester physics lecture courses.
- We constructed conceptual / math skills worksheets from PER-based materials:
  - Maryland *Tutorials in Physics Sense-Making*¹ and Minnesota *Context Rich Problems*²
  - Covering the topics of Electricity, Magnetism, and Optics.
  - Hands-on group activities often incorporated into worksheets.

Initial Implementation

- Spring 2014: planned to implement Mini-studio format in all 13 second-semester physics lab sections.
- Surprised to face massive pushback by faculty.
- Some typical reactions:
  - Majority unwillingness to deviate from traditional recitation / problem solving.\(^1\)
  - There is more material to cover than what the worksheets do.\(^2\)
  - Persuaded by student reception of worksheets and student perception of how recitation time is best spent.\(^3\)
- Less typical reactions:
  - Notion of treating students like “guinea pigs”.
  - Idea that worksheets invent misconceptions in students, rather than dissolve them.

\(^1\)Henderson and Dancy (2007), \(^2\)Dancy and Henderson (2010), \(^3\)Koening et al. (2007).
Thus, out of the 13 second-semester lab sections:

- **9 Sections:** Disapproving Lecture Instructor (DI)  
  - No Mini-studios

- **4 Sections:** Approving Lecture Instructor (A1)  
  - Mini-Studio: A1
  - Traditional Recitation: D2
  - Non PER-based Worksheet: D3
  - Non PER-based Worksheet: D3
Initial Implementation – Limitations

- Only able to implement the Mini-studio in one section.
- Have 4 lab sections to compare
  - All sections have same lecture instructor, A1.
  - Compare CSEM assessment performance across sections.

<table>
<thead>
<tr>
<th>Section</th>
<th>N Pre</th>
<th>N Post</th>
<th>N Matched</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>23</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>D2</td>
<td>22</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>D3 - 1</td>
<td>24</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>D3 - 2</td>
<td>25</td>
<td>24</td>
<td>19</td>
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## Average CSEM Results [%]

<table>
<thead>
<tr>
<th>Section</th>
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<th>Post-score (SE)</th>
<th>Raw Gain (SE)</th>
<th>Norm. Gain (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>27.5 (2.0)</td>
<td>27.3 (2.8)</td>
<td>-0.16 (3.6)</td>
<td>-1.84 (4.9)</td>
</tr>
<tr>
<td>D2</td>
<td>24.1 (1.7)</td>
<td>39.9 (3.7)</td>
<td>15.8 (3.4)</td>
<td>20.9 (4.5)</td>
</tr>
<tr>
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<td>21.7 (1.3)</td>
<td>33.1 (3.0)</td>
<td>11.4 (3.3)</td>
<td>14.1 (4.2)</td>
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Incentive Effects

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Post-test not counted a grade. Students reluctant to take test seriously without incentive.

Post-test not counted as a grade. Students encouraged to take test seriously.

Post-test not counted as a grade. Students encouraged to take test seriously.

Post-test counted as final quiz score.
## Incentive Effects

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“Floor Effect” in Pre-test\(^1,2\) seen in A1 Post-test.

\(^1\)Madsen, McKagen, and Sayre (2013), Kost-Smith, Pollock, and Finkelstein (2010).
Estimates of Apathy

- We see evidence of students not taking the CSEM seriously, especially in the Mini-studio section (A1).

- Inspecting responses for student apathy\(^1\), such as:
  - Instance of ABCDE or EDCBA patterns, or
  - The same letter choice more than 6 times in a row.

- At right, we give the lower limit on the number of students exhibiting this apathetic behavior.

\(^1\)Henderson (2002).
Discussion

- We see the Mini-studio format as an effective reformed classroom.
  - We want to extend beyond first-semester physics.

- Face several challenges and difficulties:
  - Faculty resistance to change.
    - Believing sufficient material not covered; favor traditional problem solving.
  - Students not taking CSEM seriously.
    - Incentive and apathy effects prevalent in this dataset
    - Makes assessment of initial implementation difficult.
Plans for Future Implementations

- **Move toward TA-led Mini-studios.**
  - Have Teaching Assistants administer PER-based worksheets and supervise labs.
  - Improve consistency of instruction between worksheet portion and lab portion of the Mini-studio.
  - Expose more of our future faculty to research-based instructional strategies.

- **Incorporate inquiry activities into our laboratory sessions.**
  - Adapting Investigative Science Learning Environment (ISLE) materials for use in our labs.¹

- **Create a student-centered environment fostering critical thinking:**
  - Improving students’ conceptual knowledge
  - Increase aptitude in experimental design and investigating phenomena.

¹Etkina, Murthy, and Zou (2006).