Invasion of the Cognitive Scientists: Subverting College Astronomy

Stephanie Slater
Director
Center for Astronomy & Physics Education Research

CAPER Team
Center for Astronomy & Physics Education Research
Center for Astronomy & Physics Education Research

- International, multi-institution Astronomy Education Research group
- ~200 peer reviewed publications in AER
Center for Astronomy & Physics Education Research
Astronomy at the Post-Secondary Level

<200 majors/year, no typical major

Challenging confounding variables

- 250,000 Astro 101 students
- 40% of all pre-service teachers
A new misconceptions model:

- Bad “data”
  - The facts you know that ain’t so.
- Wayward “algorithms”
  - Phenomenological primitives
- Dysfunctional “firmware”
  - Cognitive load, **spatial reasoning/thinking/skills/ability**
- Unwilling “hardware”

...Intractable bits of content.
Empirically establishing spatial thinking as the learning barrier.
Even with the tough stuff…
Not much difference.

Data Analysis and Inquiry in Astronomy
Open inquiry through faded scaffolding
The younger they are, the better they perform
“Easy Content”:
28 Hawaiian Phases of the Moon.
28 Hawaiian Phases of the Moon
Getting a 2 year old’s attention.

E ‘ohi‘ohi i na pono!

HE KA
HE IWI
HE MAKAU
HE LUPE

Ua lako ka ipu a ka ho`okele. Maika`i!
Wayfinding for 2 year olds.

Gather the needed tools!

The Bailer
The Backbone
The Fishhook
The Kite

The navigator is provisioned. Well done!
I: Here we see Kamailemua (Acentauri) rising in Na Leo Malanai. (Pointing Southeast) Where will it set?

S: Na Leo Kona! (Pointing Southwest)

I: Maika’i.
General Content
Quantitative Approaches

• Eva Kikas (2006)
  – Spatial ability > verbal ability for factual/scientific knowledge

• Slater, Heyer, Slater (2012)

<table>
<thead>
<tr>
<th></th>
<th>Vandenberg Rotation</th>
<th>Paper Folding</th>
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<tbody>
<tr>
<td>TOAST pre</td>
<td>.40 **</td>
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<tr>
<td>TOAST post</td>
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<td>.37 **</td>
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<td>TOAST &lt;g&gt;</td>
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<td>.17 n.s.</td>
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<td>.19 *</td>
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<td>.18 *</td>
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Explanatory thinking

Darrel Rudmann (2002)
- Manipulatives improved scores
- Causal model shift with S.R. score
- S.R. trumps causal model

<table>
<thead>
<tr>
<th>Model</th>
<th>Cube Comparison</th>
<th>AstroGeo</th>
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<tbody>
<tr>
<td>Scientific: Fixed Tilt</td>
<td>$x = 31$</td>
<td>$x = 19.5$</td>
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<tr>
<td>Synthetic: Wobbly Tilt</td>
<td>$x = 12.8$</td>
<td>$x = 9.8$</td>
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<tr>
<td>Naïve: Elliptic Orbit</td>
<td>$x = 9.2$</td>
<td>$x = 8.5$</td>
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**Slater (2007): Effective “Spatial Instruction”**

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Pre- Mean % Score</th>
<th>Post- Mean % Score</th>
<th>% Change</th>
<th>Norm. Gain</th>
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<tbody>
<tr>
<td>Astronomical Geography</td>
<td>39.05</td>
<td>62.38</td>
<td>+23.33*</td>
<td>34%</td>
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<tr>
<td>Rotation related events</td>
<td>54.32</td>
<td>74.59</td>
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<td>77.44</td>
<td>+50.20*</td>
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15. **Why is it hotter in summer and colder in winter?**
(Use drawings if it helps you to explain)

[Diagram of Earth and Sun positions illustrating seasonal changes]

**Notes:**
- * denotes statistically significant change.
- Norm. Gain represents the normalized gain in percentage terms.
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Moving Forward

Task-oriented instruments
Direction on Spatial Thinking Instruments
Mentoring
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