Learning Outcomes in live versus online GIS lectures

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Outline

1 Background
2 Testing three theories of learning
3 Methods
4 Results
5 Discussion/Future work
6 Conclusion
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Background
"You get it or you don't"

I took the class as an elective and it was my favorite class of the semester. However, the class falls into the "you get it or you don't" category. Luckily, I seemed to get it and I was suprised, given the class' reputation how quickly I finished most of the work. I do know several of my classmates were not as fortunate however, so be realistic with your own ability/desire before you register. I never
Most of my students lack geographic expertise.
Do spatial abilities help students learn in an introductory GIS class?

Because they seem to more broadly in STEM

“The reason spatial abilities matter early on is because they serve as a barrier; students who cannot think well spatially will have more trouble getting through the early, challenging courses that lead to dropout.”

Research Objectives/Questions

(1) Does the spatial ability that a student brings to a classroom correlate with their ability to learn geospatial concepts and applications?

(2) If it does, can we present instruction in ways to help even this playing field so that spatial abilities no longer serve as a barrier to learning?
Testing three theories of learning
Theory #1

A good lecture delivered by a good teacher in person is better than a good lecture delivered online.

Ideal of a Small Liberal Arts College
Theory #2

Students with high spatial abilities are better able to learn from difficult presentations of instruction than students with low spatial abilities.

Uttal and Cohen (2012)
Theory #3

Students with high spatial abilities benefit from well-designed presentations of instruction in ways that students with low spatial abilities do not.

Mayer and Sims (1994)
3

Methods
Worked example pedagogy

**Pre-training**
- Introduce concepts

**Worked example**
- Implement concepts with software

**Assess learning**
- Tests for transfer of knowledge

Howarth (2015)
Compared presentation delivery of pre-training lecture
<table>
<thead>
<tr>
<th>Theme</th>
<th>Tues</th>
<th>Thurs</th>
</tr>
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<tbody>
<tr>
<td>1 Intro to Flatland</td>
<td>13 Introductions</td>
<td>Lab 1</td>
</tr>
<tr>
<td>2 Euclidean Space</td>
<td>20 Distance &amp; Area</td>
<td>Lab 2</td>
</tr>
<tr>
<td>3 Topographic Space</td>
<td>27 Terrain models</td>
<td>Lab 3</td>
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<td>28 Terrain models</td>
<td>Lab 3: Mad River</td>
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<tr>
<td>Fall 2016</td>
<td>TUES</td>
<td>THURS</td>
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<td>1 Intro to Flatland</td>
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<table>
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<th>TUES</th>
<th>THURS</th>
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<td>Lab 3: Mad River</td>
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</tbody>
</table>
Live lectures Fall 2017
Online lectures Spring 2017

SLOPE

Degree of slope = \( \theta \)
Percent of slope = \( \frac{\text{rise}}{\text{run}} \times 100 \)

Degree
Percent

24.6°
50%

45°
100%

63°
200%

FOCAL OPERATION

<table>
<thead>
<tr>
<th>5</th>
<th>1</th>
<th>5</th>
<th>10</th>
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<tbody>
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<td>10</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

SLOPE
Evidence of learning outcomes

With simple diagrams

Question 2

What operation could transform this input into this output?

Note: cell size = 1m.

- RECLASSIFY
- REGION GROUP
- AREA
- EUCLIDEAN DISTANCE
Evidence of learning outcomes

With pictures of real data

Question 4

What operation and parameters would create this output (right) from this input (left)?

- HILLSHADE, altitude 30
- HILLSHADE, altitude 60
- SLOPE, degrees
- SLOPE, percent slope
Spatial ability pre-tests

Paper
Folding

Surface
Development

Ekstrom et al (1976)
Higher and lower ability groups

Combined scores from two tests
Calculated median

Higher spatial ability

Median

Lower spatial ability
Results
Subject pools

Table 1. Number of subjects for GIS and SA tests by treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>GIS Tests</th>
<th>SA Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Online</td>
<td>52</td>
<td>48</td>
</tr>
</tbody>
</table>
Testing theory #1

Is a good lecture presented by a good teacher in person better than a lecture presented online?

No, not necessarily

Table 2. Descriptive statistics, t statistics, and Cohen’s d for GIS quizzes

<table>
<thead>
<tr>
<th>Week</th>
<th>Treatment</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>St Dev</th>
<th>T statistics</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Live</td>
<td>2.25</td>
<td>10</td>
<td>6.5</td>
<td>1.88</td>
<td>T(104)=-4.09, P=0.0001*</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td>4.5</td>
<td>10</td>
<td>7.93</td>
<td>1.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Live</td>
<td>2</td>
<td>10</td>
<td>6.38</td>
<td>1.70</td>
<td>T(104)=-3.58, P=0.0005*</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td>5</td>
<td>10</td>
<td>7.48</td>
<td>1.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>Live</td>
<td>3.5</td>
<td>10</td>
<td>6.44</td>
<td>1.34</td>
<td>T(104)=-4.89, p=0.0000004*</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td>5</td>
<td>9.75</td>
<td>7.7</td>
<td>1.32</td>
<td></td>
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</tr>
</tbody>
</table>
Testing theory #2

Do high spatial abilities help students learn from difficult presentations?

Yes, they appear to be related.

**Table 3.** Correlation coefficients and significance levels between GIS and SA scores

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Paper Folding</th>
<th>Surface Development</th>
<th>Combined SA score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live</td>
<td>R=0.34 (P=0.01)*</td>
<td>R=0.36 (P=0.007)*</td>
<td>R=0.39 (P=0.003)*</td>
</tr>
</tbody>
</table>

**Table 4.** Descriptive statistics of GIS scores and t statistics for higher and lower spatial abilities

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Group</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>St Dev</th>
<th>T statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live</td>
<td>Higher</td>
<td>4.13</td>
<td>10</td>
<td>6.99</td>
<td>1.2</td>
<td>T(52)=-3.26, p=0.002*</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>3.5</td>
<td>8.5</td>
<td>5.89</td>
<td>1.26</td>
<td></td>
</tr>
</tbody>
</table>
Testing theory #3

Do high spatial abilities enable students to learn from good presentations in ways that low spatial abilities do not?

No. In this study, online presentations leveled the field.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Group</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
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<th>T statistics</th>
</tr>
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<tr>
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<td>Lower</td>
<td>3.5</td>
<td>8.5</td>
<td>5.89</td>
<td>1.26</td>
<td></td>
</tr>
<tr>
<td>Online</td>
<td>Higher</td>
<td>6</td>
<td>9.75</td>
<td>7.76</td>
<td>1.16</td>
<td>$T(46)=-0.71$, $p=0.48$</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>5</td>
<td>9.5</td>
<td>7.48</td>
<td>1.53</td>
<td></td>
</tr>
</tbody>
</table>
Testing theory #3

The effect was greater for lower ability students.

Table 5. Change in mean for higher and lower spatial abilities and effect size

<table>
<thead>
<tr>
<th></th>
<th>Higher</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live Mean</td>
<td>6.99</td>
<td>5.89</td>
</tr>
<tr>
<td>Online Mean</td>
<td>7.76</td>
<td>7.48</td>
</tr>
<tr>
<td>Change in Mean</td>
<td>+0.77</td>
<td>+1.59</td>
</tr>
<tr>
<td>Cohen’s D</td>
<td>0.66</td>
<td>1.13</td>
</tr>
</tbody>
</table>
Discussion/Future Work
The apples to oranges problem

Same content: list of GIS operations and concepts
Different modes: live versus online
Different methods of interaction

Live
Instructor controls pace
Public action to repeat
Public question →
Immediate ask

Online
Learner controls pace
Private action to repeat
Private question →
Delayed ask
Next step in analysis

Is repeat viewing related to spatial ability?

Statistics from Panopto video hosting service

Unfortunately, may be limited to amount of video time watched rather than amount of time watching videos.
Conclusion
Main Findings

(1) Online presentations can have better learning outcomes than live presentations, even in a small classroom setting.

(2) Spatial abilities do seem to help novices learn geospatial concepts from difficult presentations of instruction.

(3) Improving presentations of instruction do seem to help level learning outcomes across different spatial abilities.
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