Introduction
During the past decade, we have developed a learning progression (LP) for water in environmental systems that describes levels of achievement from informal force-dynamic to scientific model-based ways of understanding water moving through hydrosystems (Table 1, Gunckel, Covitt, Salinas & Anderson, 2012).

**Table 1. Water systems learning progression**

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Type of Account</th>
<th>Elements of Accounts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure &amp; Systems</td>
<td>Explanation</td>
<td>Connected across atomic, molecular, through large scale</td>
</tr>
<tr>
<td>Scale</td>
<td>Inverse</td>
<td>Address order events, named processes, uses school rules</td>
</tr>
<tr>
<td>Principles</td>
<td>Scientific principles, driving forces, constraining actions</td>
<td></td>
</tr>
</tbody>
</table>

**Level 4: Model-based accounts**
- Explanations of how & why water moves; connected & detailed hydrosystems
- Connected across atomic, molecular, through large scale
- Inverse way; address order events, named processes, uses school rules

**Level 3: Phenomenological (school science accounts)**
- Descriptions of what happens
- Connected systems; visible & some hidden components
- Spans micro to macro scale; some challenges linking scales

**Levels 18: Force-dynamic accounts**
- Force-dynamic descriptions of actors fulfilling purposes
- Visible, familiar components of hydrologic systems
- Visible, macroscopic scale

**Figure 1. River Map Questions**

**Question 1:** Can pollution in the river at Town B get to Town C? Explain why or why not.
**Question 2:** Describe the direction water is flowing away from Town F. How do you know the water is flowing in this direction?

Data were analyzed for change in level of achievement (Gunckel, Covitt, Salinas & Anderson, 2012). Coding involves identifying level indicators in responses (Table 3). Excellent weighting Cohen’s Kappa IRR values were achieved for level coding (>0.8). We are working on indicator coding IRR.

To investigate students’ learning pathways, we examined which L3 and L4 indicators were present in post responses.

**Results**

We focus on the majority of students responding at L2 on the pretest. Then, we focus further on those providing L3 or L4 post responses (see Table 4).

**Discussion and Implications**

The result that both the problematic principle-based indicator (3.4) and the accurate principle-based indicator (4.1) become more common as teachers gain experience suggests that student learning can be influenced differently by more or less effective LP instruction.

**Table 3. Number (percentage) of student who progress from L2**

<table>
<thead>
<tr>
<th>Group</th>
<th>Total # of Students</th>
<th>Question 1</th>
<th>Question 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2</td>
<td>211</td>
<td>112 (53%)</td>
<td>5 (4%)</td>
</tr>
<tr>
<td>L3 &amp; L4</td>
<td>501</td>
<td>300 (60%)</td>
<td>67 (22%)</td>
</tr>
<tr>
<td>L4</td>
<td>102</td>
<td>49 (39%)</td>
<td>30 (29%)</td>
</tr>
</tbody>
</table>

**Figure 4. Question 1 Indicators by Teacher Group**

**Figure 5. Question 2 Indicators by Teacher Group**

**References**


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