The Challenge of Assumptions

A Comparison of Curricular Materials and Empirical Learning Progressions in Middle Grades Plate Tectonics

Kathryn Bateman, Scott McDonald and Tanya Furman
The Pennsylvania State University
Developing a Learning Progression in Plate Tectonics

- Based on literature around student understanding of plate tectonics
- Tested iteratively through student interviews
- Total of 196 students grades 5-12 and undergraduates
- Three progress variables:
  - Plate Movement
  - Plate Dynamics
  - Intra-plate Interaction
## Learning Progression in Plate Tectonics

<table>
<thead>
<tr>
<th>Plate Movement</th>
<th>Plate Dynamics</th>
<th>Intra-Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dynamic System</strong></td>
<td><strong>Convection Currents</strong></td>
<td><strong>Plate System</strong></td>
</tr>
<tr>
<td><strong>Constant Motion</strong></td>
<td><strong>Mantle Movement (Heat)</strong></td>
<td><strong>Conservation of Mass</strong></td>
</tr>
<tr>
<td><strong>Intermittent/Historic Motion</strong></td>
<td><strong>Mantle Movement (Other)</strong></td>
<td><strong>Conveyor Belt</strong></td>
</tr>
<tr>
<td><strong>Static</strong></td>
<td><strong>Subsurface Processes</strong></td>
<td><strong>Disappearance of Plates</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Events</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Surface Processes</strong></td>
<td><strong>Gaps Between Plates</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Static</strong></td>
</tr>
</tbody>
</table>
Research Question

Compare patterns of student concept development between **theoretical materials** and an **empirically based** learning progression around the paradigm of Plate Tectonics.
Content Standards

1996

2012

2013
Project 2061 Resources

- AAAS 1989 and 2013
- AAAS 1993 and 2009
- AAAS 2001 and 2007
Teacher Resources

Driver et al
1994 and 2013

Hazen and Trefil
1991 and 2009
K-2: “Changing Things”

3-5: Earth’s geological features/events

6-8: Features that \textit{shape} Earth’s surface, but not \textit{formation}

9-12: Theory and phenomena of plate tectonics
  - radioactive decay’s role in rock dating and geological time
Earth Science not taught in High Schools

Postponing integration of evidence, ideas to grades 9-12 effectively ensures they will not be taught at all

(AGI, 2013)
Standards documents avoid systemic understanding

- CTS: Middle grades students not asked to employ systemic understanding
- LP: Students show systemic understanding when taught that way
Focus on history leads to confusion

- CTS: focus on explaining history of plate tectonics
  - Fossils, continent shapes, magnetic striping

- Historical evidence in instruction led to student non-normative understandings:
  - plates only move sometimes
  - Magnets cause plate movement
Small focus misses Big Ideas

- Current K-8 instruction covers pieces of the whole
  - earthquakes and volcanoes
  - phenomena that shape Earth’s surface
  - define Earth’s surface as made of plates

- This approach leads to piecemeal understanding

- Students focus on boundaries and static features

- Systemic understanding delayed or prevented
NGSS: Better, but not sufficient

- 4th grade: Historical evidence of plate tectonics
- 6th-8th grade: Tectonic processes generate new ocean floor at ridges and destroy sea floor at trenches
- High School: Unifying theory of plate tectonics
  - Radiometric decay
  - Convection and heat transfer
  - Integration of observational evidence
Implications for college teaching

- Be aware of students’ limited background
- Prior learning focused on pieces, not system
- Help students create deeper understanding by challenging their non-normative models