Hands-on Or Minds-on: Cognitive Activities In Performance Assessments

--An Empirical Study On Think Aloud

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Pros and Cons of Performance Assessment

Pro
• Follows from learning theory
• Measures science problem solving
• Focuses on science education on inquiry

Con
• Is expensive
• Is labor intensive
• Is sensitive to task-, occasion-, and method-sampling
Do Performance Assessments Promote Higher-order Thinking?

**NO:** poorly designed performance assessments cannot capture the essence of students' achievement

**YES:** well designed PA can distinguish students’ levels of explanations, plans, strategies, and monitoring.

(Source: Baxter et al. 1991, 1996)
Our Study

Our Concern:
--Do performance assessments gauge scientific thinking, problem solving, content knowledge, and skills?

Our Logic:
--If performance assessments gauge scientific thinking, high achievers should exhibit this thinking more often and with better quality than low achievers.
Our Model

Cognitive Activities

Think Aloud
Code Prop.

Achievement

PA Scores
Electric Mysteries
Daytime Astronomy

Flashlight

Sticky Towers

Student Notebooks and Pencils
Aquacraft
## Performance Assessment Characteristics

<table>
<thead>
<tr>
<th>Performance Assessment</th>
<th>Reasoning Dimension</th>
<th>Content Demand</th>
<th>Process Openness</th>
<th>Task Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Mysteries</td>
<td>Basic Knowledge</td>
<td>Medium</td>
<td>Open</td>
<td>Component-Identification</td>
</tr>
<tr>
<td></td>
<td>Reasoning</td>
<td></td>
<td></td>
<td>Investigation</td>
</tr>
<tr>
<td>Daytime Astronomy</td>
<td>Spatial Mechanical</td>
<td>Medium</td>
<td>Medium Open</td>
<td>Observation Investigation</td>
</tr>
<tr>
<td>Aquacraft</td>
<td>Quantitative Science</td>
<td>Rich</td>
<td>Medium Open</td>
<td>Comparative Investigation</td>
</tr>
</tbody>
</table>

Source: adapted from Ayala et al., 2001
Methods

Participants:
34 high school students drawn from and representative of a large study

Procedure:
• Spontaneous think aloud
• Two-rater coding
• 13 cognitive activity categories coded
<table>
<thead>
<tr>
<th>Overarching Blocks</th>
<th>Task Mechanics</th>
<th>Self-regulation</th>
<th>Science Activity Process and Reasoning</th>
<th>Knowledge and Information Sources</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>Reading and Test Taking</td>
<td>Monitoring</td>
<td>Planning, Conducting, Observing, Conjecturing, Concluding</td>
<td>Science Knowledge, Everyday Life Knowledge, Test Wiseness</td>
<td>Meaningless</td>
</tr>
</tbody>
</table>
The Link Between Cognitive Activities and Performance

- Reading
- Task Taking
- Monitoring
- Planning
- Conducting
- Observing
- Conjecturing
- Concluding
- Explaining
- Science content
- Everyday life knowledge
- Test Wiseness
- Meaningless
- Total
The Link Between High Level Cognitive Activities and Performance

![Bar chart showing the link between high level cognitive activities and performance.](image-url)
<table>
<thead>
<tr>
<th>Cognitive Activity</th>
<th>Monitoring</th>
<th>Planning</th>
<th>Conducting</th>
<th>Observing</th>
<th>Conjecturing</th>
<th>Concluding</th>
<th>Explaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands-on</td>
<td>0.118</td>
<td>0.277</td>
<td>0.829</td>
<td>0.860</td>
<td>0.260</td>
<td>0.645</td>
<td>0.473</td>
</tr>
<tr>
<td>Minds-on</td>
<td>0.841</td>
<td>0.614</td>
<td>0.267</td>
<td>0.335</td>
<td>0.824</td>
<td>0.720</td>
<td>0.755</td>
</tr>
</tbody>
</table>

**Hands-on and Minds-on**
Predicting Performance from Cognitive Activities

Performance Score = .226*Hands-on + .654*Minds-on

$R^2 = .598$
Conclusions

• PA gauges higher-order thinking: high achievers engage in more higher-order cognitive activities and in higher quality cognitive activities.

• Different types of higher-order cognitive activities are positively correlated.

• Minds-on plays a more important role than hands-on in predicting PA scores.