Resource Activation Patterns In Expert Problem Solving

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Study Overview

Motivation

To develop the resource-based model of cognition [1], the following questions need to be answered:

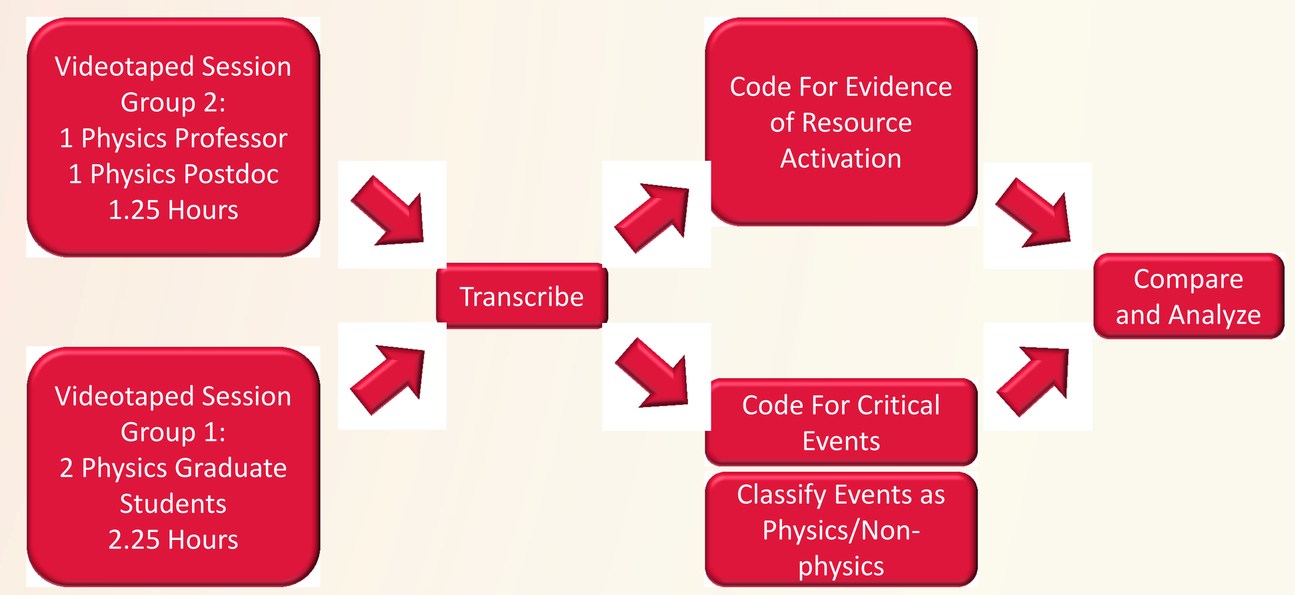
1. What resources do students have available to them?
2. What patterns of resource activation can be identified?
3. What resources and activation patterns are productive in which different contexts?

Previous work [1-7] has begun to provide answers, but in the context of novice studies. This is sufficient to answer the first two questions, but deeply answering the third question requires studying the reasoning of experts.

Study Goals

In this study, we further develop the resource-based model of cognition by searching for and identifying productive resources and resource combination patterns present in expert reasoning. We focus on determining whether critical moments in the problem solving process are characterized by the combination of p-prims, conceptual resources, and epistemological resources, a pattern which has been observed previously in novices [7], and whether any specific resources appear to be more important than others during critical events.

Phases of Study

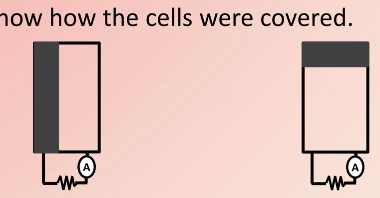


Data Collection

We videotaped two pairs of experts as they solved a novel problem about solar cells in order to investigate how physics experts reason in challenging situations. The first part of the problem is shown below. The videotaped sessions were then transcribed in full to allow for further investigation.

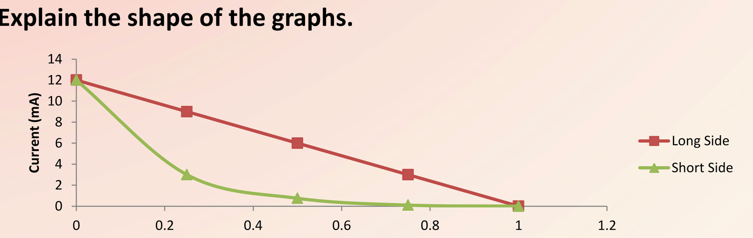
Part 1

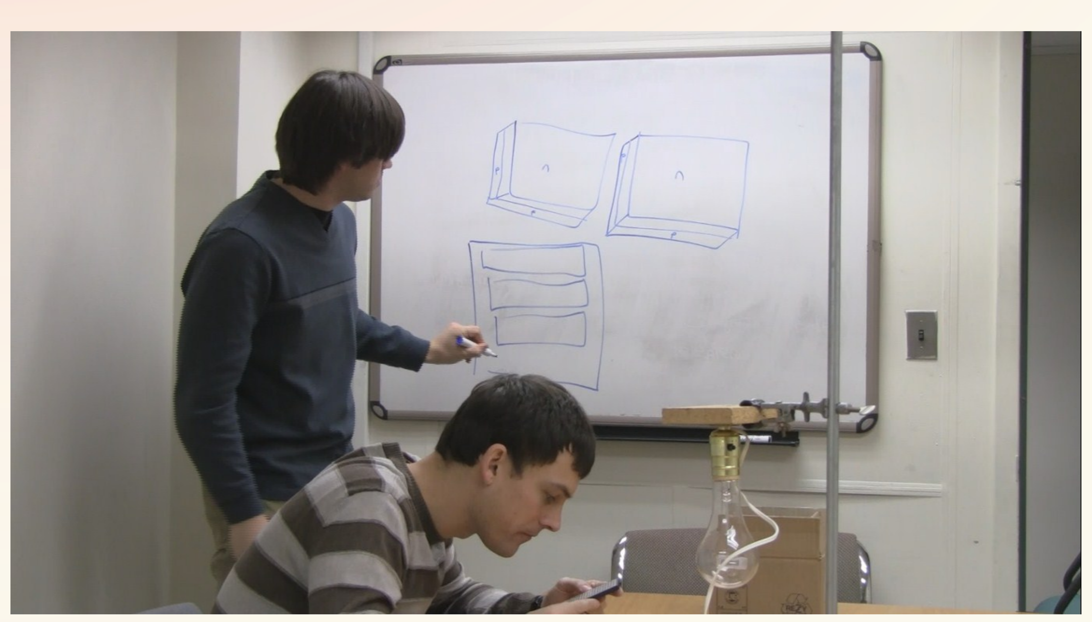
We conducted two experiments with a solar cell. In both experiments the solar cell was connected to a resistor (R = 75 Ohm) in series and illuminated with a 150-W bulb. During the illumination we covered a part of the cell: in the first experiment the cover was along the long side, and in the second experiment it was along the short side. The sketches below show how the cells were covered.



Covering the long side (left) and short side (right) of the solar cell.

The measurements below show how the current through the resistor depends on the relative area of the solar cell covered by black paper. **Explain the shape of the graphs.**





Coding

The transcripts were coded for evidence of resource activation. Resources were classified as either a p-prim, conceptual resource, or epistemological resource and given a name based on resources identified in previous studies or emergent trends in the data.

Portion of Transcript Coded for Resources

Example Segment of Coded Transcript	Resources in order of appearance	Resource type
Evidence of p-prims in blue, conceptual resources in red, and epistemological resources in green.		
A: Yeah. When you cover up, when you cover up one of the cells, that cell is now just like a chunk of silicon that's not excited. D: Right, it becomes like a…uh – A: Big resistor. D: Resistor, yeah. A: Yeah. So that's why it's going to cut the current down a lot more. If we, when we come in from the long side and just cover up parts of each cell, then we're going to, um, none of the cells really become a resistor, it's just like, um like, each of them is still contributing something. D: Ok. A: So the effective resistance is less than if we cover up one whole cell. Does that make sense?	Contrasting Cases (entire passage) Discrete Solar cell as resistor Providing explanations which identify a mechanism Ohm's P-prim Continuous Solar cell as resistor Adding up Solar cell as a resistor Discrete Encouraging sense making	Epistemological P-prim Conceptual Epistemological P-prim P-prim Conceptual P-prim Conceptual P-prim Epistemological

The transcripts were separately coded for critical events [8], instances during which conceptual breakthroughs or notably incorrect reasoning occurs. Critical events were further classified as physics or non-physics critical events based on the question the subject was attempting to answer in each event.

Example physics vs. non-physics critical events

Non-physics	Physics
Question: How does the construction of the solar cell make the two situations described in the problem unique?	**Question:** How do the individual p-n junctions function differently in the two situations and how does this explain the difference in the observed current vs. coverage graphs?
D: And so, so, that would mean that as you bring the paper in from this side, you're only partially covering them. A: So that, yeah. D: And then as you bring in the paper from this side… A: The long way. D: You're, you're actually covering entire – A: Individual cells. D: Yeah. Yeah. A: Yeah…Yeah. So, so the difference between the two approaches is in one situation we're covering up like one cell at a time and on the other side we're covering up parts of all the cells.	A: Yeah. When you cover up, when you cover up one of the cells, that cell is now just like a chunk of silicon that's not excited. D: Right, it becomes like a…uh – A: Big resistor. D: Resistor, yeah. A: Yeah. So that's why it's going to cut the current down a lot more. If we, when we come in from the long side and just cover up parts of each cell, then we're going to, um, none of the cells really become a resistor, it's just like, um like, each of them is still contributing something. D: Ok. A: So the effective resistance is less than if we cover up one whole cell. Does that make sense?

Analysis

Physics vs. Non-Physics Critical Events

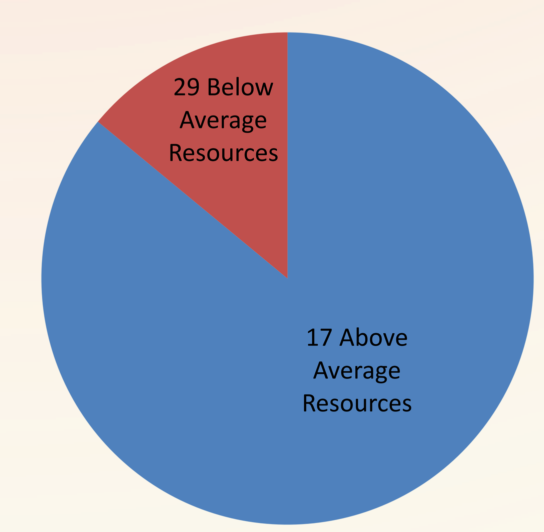
After coding critical events and resources we determined the percentage of critical events with evidence of all three types of resources. The results, shown below, show evidence of dissimilar reasoning patterns during physics and non-physics critical events.

Event Type	Number of Events	Percent with All Three Types
All	68	78%
Physics	50	86%
Non-Physics	18	44%

Epistemological Resources

We specifically focused on epistemological resources that were activated during critical events due to the importance of epistemology on learning [5,9,10]. An average epistemological resource was activated in 4.15 critical events. The 17 resources that showed above average activation levels during critical events made up 86% of the instances of epistemological resource activation during critical events. While some resources have gained priority in expert reasoning, a variety are still important in the problem solving process.

Epistemological Resource Usage During Critical Events



Most common epistemological resources

Knowledge can be gained through:

- Reconciling observations with prior knowledge
- Directly perceiving information
- Representing information multiple ways
- Being aware of one's own thinking (metacognition)
- Being aware of other's thinking (social metacognition)
- Being aware of explicit and implicit assumptions
- Providing explanations which identify a mechanism
- Building models which are consistent with observations/prior knowledge
- Building models which predict and explain
- Considering models as imperfect descriptors
- Contrasting cases
- Reasoning analogically
- Encouraging sense making
- Reasoning algebraically
- Interpreting representations literally
- Personifying inanimate objects
- Requiring justifications

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