Developing and Assessing Scientific Abilities with Video Problems

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Video Problems may be found at: http://paer.rutgers.edu/pt3
Acknowledgements

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Outline

1. Introduction: Why abilities rather than concepts?
2. Scientific Abilities
3. Tasks to develop scientific abilities
4. Assessment
5. Rubrics (with examples)
7. Examples
8. Discussion and Conclusion
Introduction: Why abilities rather than concepts?

- What do we want students to learn?
- What is a concept? Do concepts exist?
  - Can students discover the world as we see it, without guidance?
- Thinking like a scientist: What does this entail?
  - Engagement in and use of the values, tools and practices of scientists.
  - Learning to participate in specialized human activity.
Why abilities rather than concepts?

- Values:
  - Data driven (empiricism)
  - We only accept falsifiable explanations (e.g., “God” is not a scientifically acceptable explanation)

- Tools and Techniques
  - Lab equipment
  - Hypothetico-deductive reasoning
  - Multiple representations (complex semiotic system) used to make meaning
  - Etc…
Abilities versus Skills

- **Knowledge**
  - **Ability**
    - **Skill**

- **Belief + Truth**

- **Ability to reconstruct knowledge and apply/use knowledge**

- **Automatic (driving, walking etc) - There are no cognitive skills.**

Use of cognitive abilities requires reflective thought all the time
What are the abilities?

1. The ability to represent in multiple ways
2. The ability to design and conduct an experiment. (Three types: Observation, Testing and Application.)
3. The ability to collect and analyze data
4. The ability to construct, modify and apply relationships/explanations (modeling ability)
5. Ability to evaluate
6. The ability to communicate ideas
7. The ability to think divergently
Framework

ISLE

Observational experiments

Different

Rejected model

Patterns

Possible model: Qualitative/quantitative explanation

Testing Experiments:
If - then, but/and - therefore

Different

Predict the outcome

NO

More testing Experiments

Predictions are based on the proposed model

The results of the testing experiments suggest how we proceed...

Practical applications:
• Problem solving: Everyday life applications
• Predictions of new phenomena
Example: Modeling ability

- Ability to construct an explanation based on data
- Ability to apply a explanation/model to make a prediction about the outcome of a new situation
- Ability to chose/identify a explanation/model applicable to a particular situation
- Ability evaluate the applicability of a model to a given situation
  - Ability to identify assumptions: (Do we ignore friction? Is ignoring friction valid in this situation?), (Do we assume the object is a point particle or must we treat it as an extended object?)
  - Ability to understand how assumptions will affect results (E.g.: If friction is not negligible what happens to the ball?)
- Ability to revise an explanation based on new evidence
Tasks for developing abilities

Practice style tasks

- Multiple representation tasks
  - Abilities used: multiple representations

- Modeling tasks
  - Abilities used: Modeling ability

- Evaluation tasks
  - Abilities used: multiple reps, modeling.
Tasks for developing abilities

Putting it all together

- Experimental design tasks
  - Abilities used: All!

- Video problems
  - Abilities used: Data analysis, modeling, application experiment, making a judgment.

- Anomalous data problems
  - Abilities used: Data analysis, modeling
Assessment

- Assessment must reflect educational values
- We assess both abilities and content

<table>
<thead>
<tr>
<th>Summative Assessment</th>
<th>Formative Assessment</th>
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<tr>
<td>Emphasis on the process of learning and immediate feedback</td>
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<td>Promotes examination of the process of knowledge</td>
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Confidence = ability to succeed
Formative self assessment

Where are you now?

How can you get there?

Where do you need to go?
Rubrics for self-assessment and formative assessment

- Talk a bit about making a rubric.
- Assess some student work.
What are video problems?

- One video of some physical event or situation
- There are two or more ways of measuring some physical quantity in the video
- Students decide what to measure, take data, apply models, estimate uncertainties and compare the answers from the two methods
- Examples…
Why Video Problems?

• Promoting epistemic cognition
  • Ill-defined, complex problems

• Promoting scientific abilities
  • Modeling, data analysis

• Concrete experiences
  • Move back of chapter problem into real world context

• Promoting decision-making
  • Students make scientific decisions about what to assume/neglect etc…

• Helping students see the coherence of physics
  • Different methods

• Alleviating cognitive load
  • Videos can be used to present “clean”, unambiguous data.
Where/When?

ISLE

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Rejected model

Different

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Possible model:
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Predict the outcome

More testing Experiments

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Practical applications:
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- Predictions of new phenomena
Where/When?

Students should attempt video problems after they have constructed a relationship/ explanation of a related phenomenon and feel comfortable applying it.

- As a recitation formative assessment assignment (with a rubric for self assessment)
- As a laboratory experiment (with a rubric for self assessment)
- As a homework problem (with a rubric for self assessment)
- As an exam question
Video Problems as formative assessment

- Where are you now? - provided solution guidelines after the problem is solved.
- What do you need to do to get there? - self-assessment rubric after the problem is solved.
Examples

- Show some examples
- Look at student work
- Evaluate work with rubric
Discussion and Conclusion

- Students are participating in a complex system of tools, techniques, values, ways of seeing the world etc…

- Want student to acquire tools and techniques of physics in addition to learning a set of concepts

- How are we going to assess what we value?
  - Identified scientific abilities
  - Wrote rubrics to assess those abilities
  - Devised tasks to develop abilities
  - Applied it all in a meaningful way
Discussion and Conclusion

- Where are we now?
  - Have written rubrics that work
  - We are using and assessing the tasks and rubrics in algebra based physics, for life sciences - total of 700 students per semester

- Where do we need to go?
  - Look for trends. Are students improving in the things we value?
  - Look for correlations: Are students showing better abilities also “getting” the concepts?
  - Write and disseminate the rubrics and tasks

- [http://paer.rutgers.edu/ScientificAbilities/](http://paer.rutgers.edu/ScientificAbilities/)
- [http://paer.rutgers.edu/pt3/](http://paer.rutgers.edu/pt3/) (for video problems and anomalous data tasks)