Workshop – Research Tools to Uncover the “Hidden Curriculum”

Jen Docktor  
University of Illinois

Edit Yerushalmi  
Weizmann Institute for Science

Ken Heller, Pat Heller, Leon Hsu, Qing Xu  
University of Minnesota

Charles Henderson  
Western Michigan University  
in absentia

Andy Mason  
University of Minnesota  
in absentia

73% dark energy

23% dark matter
What is the Hidden Curriculum?

• Goals of the faculty which are not articulated to the students
• Learning of the students that are not intended by the faculty
• Expectations of the other stakeholders in the learning outcomes

The hidden curriculum causes dissatisfaction and frustration for everyone

• Students: I work hard but can never satisfy my teacher.
• Faculty: Most of my students are not good enough for my class.
• Engineering faculty: Physics classes don’t teach anything useful.
• Upper level Physics faculty: Students are not prepared.
• Curriculum developers: Faculty refuse to use pedagogy that works.
The “hidden curriculum” resides in (at least) 5 places

1. What the instructor believes the student should and can learn.
2. What the instructor intends to teach.
3. What research says students need to learn.
4. What other “stakeholders” such as faculty teaching these students downstream (physics & non-physics) and employers expect.
5. What students actually learn.

To find out about 1 & 2 requires probing the beliefs and values of the instructor.
   Artifact based interviews is one way of doing this.
To find out about 5 requires assessment of the students’ actions.
   Analyzing student written work is one way of doing this.

3 & 4 are well documented but could use some further study – not addressed here

This workshop gives a brief overview of tools to investigate

How do 1 & 2 align with 3?
How do 1 & 2 align with 5?
How does 3 align with 5?
Problem Solving: an excellent context for uncovering the “hidden curriculum”

- It is a typical assessment tool used by instructors for a course.
- True problem solving involves fundamental principles, conceptual knowledge, visualization, metacognition, logical organization, creativity, insight, and mathematical skills.
The Plan

Background Information –

1. Uncovering Faculty Beliefs - Edit Yerushalmi
   Illustrative activity – collecting your ideas on problem solving

2. Analyzing student written problem solving – Jen Docktor
   Illustrative activity – assessing student problem solving

3. Alignment of faculty & research curriculum – Andy Mason
   Illustrative activity – connecting your ideas on problem solving to the problem solving assessment.
Studying the Hidden Curriculum
- Faculty Beliefs

Edit Yerushalmi
Weizmann Institute for Science, Israel
Charles Henderson
Western Michigan University
Ken Heller, Pat Heller
University of Minnesota
Focus:
Physics faculty beliefs and values about the teaching and learning of problem solving

1 What students should do when problem solving (PS)?
2 How students should learn in the context of PS?
3 What do students actually do when PS?
4 How can they help students’ learning in an optimal situation?

The answers to these are part of the Hidden Curriculum
How *shouldn't* we study the hidden curriculum?

"Concerning the Interview", Mark Twain
Newly Published Mark Twain Essay, July 7, 2010, PBS:

The Interview ...is perhaps the poorest of all ways of getting at what is in a man. In the first place...you are afraid of the interviewer, and that is not an inspiration.

You close your shell; you put yourself on your guard; you try to be colorless... and talk all around a matter without saying anything: and when you see it in print, it makes you sick to see how well you succeeded.
How should we study the hidden curriculum?

Assumption: instructional decisions are the resolutions of conflicting beliefs \( \Rightarrow \)

Needed: a data collection tool that elicits different beliefs in different contexts, and their resolution

The data collection tool should reflect decision making context

\( \Rightarrow \) Artifacts comparison approach

Get instructors to uncover decision making by focusing on concrete artifacts that they routinely design and assess.

Interview design

1 baseline problem, 4 Problems, 5 Student Solutions, 3 Instructor Solutions, revolving around the baseline problem

1.5 h, 4 parts, video documentation

Parts 1-3:
3 classroom contexts

Students solve problems

Instructor models PS

Grading

During each of the 1st 3 parts: general and specific questions:

1) General: How / why do you use instructor solutions?
2) Specific: How are they similar/different to yours? Why?
3) What components that are important in the PS process are represented in the various solutions
Baseline problem

• Could reasonably be given in most calculus-based introductory physics courses (verified with physics faculty at several other institutions), indeed, was taken from a final exam at the University of Minnesota, designed and approved by a group of four physics instructors.

Homework Problem

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. Assume also that air resistance can be neglected. The stone weighs 18 N.

The correct answer is 1292 N

• Difficult for an introductory physics course, rich enough to allow for interesting variations. An average student has to use an exploratory decision making process as opposed to an algorithmic procedure. Required several important physics concepts.
Problems

Differing features

1. Includes drawing
2. State the target quantity
3. Broken into sub problems
4. Includes motivation
5. requires qualitative analysis
6. Abstract/contextual
7. multiple-choice

Problem A

A 1.8 kg mass is attached to a frictionless pivot point and is moving in a circle at the end of a 65 cm string. The string breaks when the mass is moving directly upward and the mass rises to a maximum height of 23.0 m. What is the tension in the string one-quarter turn before the string breaks? Assume that air resistance can be neglected.

A) What velocity, \( v_r \), must the stone have when released in order to rise to 23 meters above the lowest point in the circle?
B) What velocity, \( v_r \), must the stone have when it is at its lowest point in order to have a velocity \( v \), when released?
C) What force will you have to exert on the string at its lowest point in order for the stone to have a velocity \( v \)?

Problem B

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone zene and it makes its final turn around the circle, you are holding the end of the string at the lowest point.

A) 1292 N
B) 1258 N
C) 1248 N
D) 1210 N
E) None of the Above

Note: The drawing is not shown.

Problem C

You are working at a construction site standing on the top of the building as it's being built. You throw a bag of nails up and then back down again, but the bag isn't strong enough to throw it up very high. You tie the bag of nails to the end of a string. You try this, and after a little while a circle you notice that you no longer see a circle. You think that if you release the bag that it will go up to your co-worker. As you hurl the bag of nails around, however, you begin to worry that the string might break, so you stop and attempt to decide before continuing. According to the string manufacturer, the string is designed to hold up to 100 lbs. You know from experience that the string is most likely to break when the bag of nails is at its lowest point.
Students' Solutions

Student Solution D
Explains his reasoning
Reveals mistakes

Student Solution E
No Reasoning
Doesn't reveal mistakes

\[ V^2 = 2gh \]
\[ F - mg = \frac{m \cdot 2gh}{R} \]
\[ F = 18 + \frac{2 \cdot 18 \cdot 23}{0.65} = 1292 \text{ N} \]

\[ \frac{1}{2} mv^2 = mg \cdot h \]
\[ v^2 = 2gh \]
\[ v = \sqrt{2 \cdot (-9.8) \cdot 23} \]
\[ v = 21.2 \]

Energy conservation between top and release

\[ T \& V \text{ so no work done} \]
\[ \text{Energy is conserved and velocity is the same} \]

\[ \Sigma F = ma \]
\[ T - mg = \frac{mv^2}{R} \]
\[ T = 18 + \frac{18 \cdot 21.2^2}{0.65} \]
\[ = 1292 \text{ N} \]
Hands on experience: instructor solutions
1st task, in groups of 3, 7 min

Instructors’ solutions can represent aspects/components that are important in problem solving (e.g. things student needs to know or be able to do).

What aspects/components that you consider important are represented (or missing) in these instructor solutions?
Hands on experience: Categorizing cards
2\textsuperscript{nd} task, in groups of 3, 7 min

Too detailed ⇒ Please put these components into categories of your choosing & please name these categories

<table>
<thead>
<tr>
<th>Components</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Categories</td>
<td>Components</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Components</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>
Indeed, we did this

1 baseline problem, 4 Problems, 3 Instructor Solutions, 5 Student Solutions, revolving around the baseline problem.

1.5 h, 4 parts, video documentation

Parts 1-3:
3 classroom contexts

Part 4: knowledge organization

What components that are important in the PS process are represented in the various solutions? Recorded on index cards by the interviewer.

Interviewees categorize the cards and name each category.

Asked regarding the categories:
• How did your students perform on X?
• How would you help them to improve in X?
PS components recorded on index cards

- translating English statements to physics equations
- Break the problem into steps
- Knowing conservation of energy
- Draw vector diagrams
- Substitutes to get answer
- Recognize when something is missing
- Comment on result
Categorized cards (by interviewee)

OVERALL APPROACH
- Translating English statements to physics equations
- Break the problem into steps

PROCEDURAL
- Draw vector diagrams
- Substitutes to get answer

UNDERSTAND PHYSICS
- Knowing conservation of energy

MATURE
- Recognize when something is missing
- Comment on result
Findings: Map of Instructor's Beliefs

- Appropriate knowledge [Fig. 3]
- Knowledge & Skills Related to Problem Solving (1,2,3,4,5,6)
  - demonstrated by solving novel problems (4)
- Affective Characteristics (2)
  - e.g.
    - PHYSICS CONCEPTS (1,2,3,4,5,6)
    - finding physics fun, interesting, satisfying (2)

Consists of
- APPRAOCH TO SOLVING A PROBLEM (1,2,3,4,5,6)
- SPECIFIC TECHNIQUES (1,2,5,6)
- SELF EVALUATION (1,2,3,4,6)
- Physicists beliefs about problem solving (1,3,6)
- Physicists style (5)
Findings: Map of Instructor’s Beliefs

- **PHYSICS CONCEPTS**
  - conservation of energy (1,2,3,4,5,6)
  - have a good sense of what centripetal acceleration does (1,4)
  - know physics laws and limits of application (1)
  - understand dynamics and rotational dynamics (3)
  - understand that tension on a string on an object that’s going around in a circle does no work (4)
  - fully grasp ideas behind problems (4)
Findings: Map of Instructor's Beliefs

Consists of

- Appropriate knowledge [Fig. 3]
  - Knowledge & Skills Related to Problem Solving (1, 2, 3, 4, 5, 6)
    - Demonstrated by solving novel problems (4)
- Affective Characteristics (2)
  - e.g.
    - Physics concepts (1, 2, 3, 4, 5, 6)
    - Approach to solving a problem (1, 2, 3, 4, 5, 6)
    - Specific techniques (1, 2, 5, 6)
    - Self evaluation (1, 2, 3, 4, 6)
    - Physicists beliefs about problem solving (1, 3, 6)
    - Physicists style (5)
- Finding physics fun, interesting, satisfying (2)
Findings: Map of Instructor's Beliefs

- having a strategy and being able to verbalize it (3,5)
- not resorting to bad habits (e.g. pulling formulas out of a hat) (3)
- have good habits (e.g. start by stating knowns and unknowns, develop a strategy to arrange principles) (4)
- organize decision making on a tree structure (5)
- exploring (1)
- analyze each step (2)
- reasoning (3)
- think about problem in a logical way (5)

- being able to identify the physics concepts that underlie the solution (2,3,4,6)
- being able to categorize the problem so you know how to solve it (5)
- being able to recognize what is relevant and what is not (2,4)
- have a feeling for what things would work (1)
Findings: Map of Instructor's Beliefs

- Appropriate knowledge [Fig. 3]
  - Knowledge & Skills Related to Problem Solving (1,2,3,4,5,6)
  - Demonstrated by solving novel problems (4)

- Affective Characteristics (2)
  - e.g.
    - Physics Concepts (1,2,3,4,5,6)
    - Approach to solving a problem (1,2,3,4,5,6)
    - Specific techniques (1,2,5,6)
    - Self evaluation (1,2,3,4,6)
    - Physicists' beliefs about problem solving (1,3,6)
    - Physicists' style (5)

Finding physics fun, interesting, satisfying (2)
Findings: Map of Instructor's Beliefs
Reflection on the task

What were the advantages/disadvantages of the task as means to get at your “hidden curriculum”?
- "Measures" for data collection
  “Artifacts comparison” interview approach

<table>
<thead>
<tr>
<th>Guba &amp; Lincoln “measures”</th>
<th>Interview features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credibility ~ validity</strong></td>
<td>Encouraging Introspection: comparison between artifacts differing in pedagogical features</td>
</tr>
<tr>
<td></td>
<td>Identifying strong/weak beliefs: triangulation, 3 teaching contexts, General &amp; specific</td>
</tr>
<tr>
<td></td>
<td>Allowing natural language questions regarding interviewee’s categories</td>
</tr>
<tr>
<td></td>
<td>Making the interviewee comfortable baseline problem sent in advance</td>
</tr>
<tr>
<td><strong>Conformability ~ objectivity</strong></td>
<td>Artifacts reflect the research literature to trigger thoughts about the distribution of roles between instructor &amp; student, desired and perceived students’ reasoning. (i.e. Student solutions reflect expert vs, novice PS)</td>
</tr>
<tr>
<td><strong>Dependability ~ reliability</strong></td>
<td>Reproducibility through Pre defined questions</td>
</tr>
</tbody>
</table>
Assessing Student Problem Solving Using a Rubric

Jennifer L. Docktor
docktor@illinois.edu

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Rubrics

- Commonly used to measure complex skills
- Defined by a set of categories
- Typically a table or grid where cells identify criteria met to attain a score
- Convert qualitative data \(\rightarrow\) quantitative data


Rubric Category Descriptions

- **Useful Description**
  - organize information from the problem statement symbolically, visually, and/or in writing.

- **Physics Approach**
  - select appropriate physics concepts and principles

- **Specific Application of Physics**
  - apply physics approach to the specific conditions in problem

- **Mathematical Procedures**
  - follow appropriate & correct math rules/procedures

- **Logical Progression**
  - overall the solution progresses logically; it is coherent, focused toward a goal, and consistent (not necessarily linear)

Based on previous work at Minnesota by:

J. Blue (1997); T. Foster (2000); T. Thaden-Koch (2005);
P. Heller, R. Keith, S. Anderson (1992)
Research Basis of Rubric

Rubric categories were derived from research on experienced & inexperienced problem solvers:

**Useful Description**
- (Larkin, McDermott, Simon, & Simon 1980; Reif & J. Heller 1982)

**Physics Approach**
- (Chi et al. 1981; de Jong & Ferguson-Hessler; J. Heller & Reif 1984)

**Specific Application of Physics**
- (Larkin 1979; Schoenfeld & Hermann 1982; Eylon & Reif 1984)

**Math Procedures**
- (Polya, 1945; Reif, Larkin, & Brackett 1976)

**Logical Progression**
- (Chi 2006; Singh 2002; Reif & J. Heller 1982)

Also developed from applying the rubric to student and instructor solutions
Rubric Scores (in general)

<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete &amp; appropriate</td>
<td>Minor omission or errors</td>
<td>Parts missing and/or contain errors</td>
<td>Most missing and/or contain errors</td>
<td>All inappropriate</td>
<td>No evidence of category</td>
</tr>
</tbody>
</table>

**NOT APPLICABLE (NA):**

<table>
<thead>
<tr>
<th>NA - Problem</th>
<th>NA - Solver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not necessary for this problem (i.e. visualization or physics principles given)</td>
<td>Not necessary for this solver (i.e. able to solve without explicit statement)</td>
</tr>
</tbody>
</table>
# Problem solving rubric at a glance

<table>
<thead>
<tr>
<th>CATEGORY: (based on literature)</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful Description</td>
<td></td>
</tr>
<tr>
<td>Physics Approach</td>
<td></td>
</tr>
<tr>
<td>Specific Application</td>
<td></td>
</tr>
<tr>
<td>Math Procedures</td>
<td></td>
</tr>
<tr>
<td>Logical Progression</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>NA (P)</th>
<th>NA (S)</th>
</tr>
</thead>
</table>

- **Want**
  - **Minimum number of categories that include relevant aspects of problem solving**
  - **Minimum number of scores that give enough information to improve instruction**
Problem-Solving Task

Homework Problem

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. Assume also that air resistance can be neglected. The stone weighs 18 N.

The correct answer is 1292 N
This is a centripetal force problem \( F = m \frac{v^2}{r} \)

Free Fall:
\[
\begin{align*}
\text{Position} & : y_0 + \text{max. height} \\
\text{Velocity} & : v_y = v_0 - gt \\
\text{Time} & : t = \frac{v_y}{g} \\
\text{Displacement} & : \Delta y = y_0 + v_0 t - \frac{1}{2} g t^2 \\
\text{Corrected} & : \Delta y = y_0 + v_0 t - \frac{1}{2} g \left( \frac{v_y}{g} \right)^2 \\
\text{Wrong} & : \Delta y = (y_0 - \frac{1}{2}) \frac{v_0^2}{g} \\
\end{align*}
\]

\[
\frac{\Delta y}{y_0 - \frac{1}{2}} = \frac{v_0^2}{g}
\]

Force Exerted by me
\[ F = ma = m \frac{v_0^2}{R} \]
\[
\begin{align*}
\text{Forces} & : F_{\text{net}} = m a \\
\text{Corrected} & : \frac{mg \Delta y}{(y_0 - \frac{1}{2}) R} \\
\text{Wrong} & : \frac{18 \cdot 22.65}{(0.65 - 0.65) (0.65)} = 4192 \text{N}
\end{align*}
\]
Energy conservation between top and release

\[ \frac{1}{2}mv^2 = mgh \]

\[ v^2 = 2gh \]

\[ V = \sqrt{2(-9.8)23} \]

\[ V = 21.2 \]

between release and bottom \( T + V \) so no work done

\( T \) and \( V \) are conserved and velocity is the same

\( \Sigma F = ma \)

\[ T - mg = \frac{mv^2}{R} \]

\[ T = 18 + \frac{18 \cdot 21.2^2}{9.8 \cdot 0.65} \]

\[ = 1292N \]
References


docktor@illinois.edu
http://groups.physics.umn.edu/ph ysed

Additional Slides
<table>
<thead>
<tr>
<th>USEFUL DESCRIPTION</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>NA(Problem)</th>
<th>NA(Solver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The description is useful, appropriate, and complete.</td>
<td>The description is useful but contains minor omissions or errors.</td>
<td>Parts of the description are not useful, missing, and/or contain errors.</td>
<td>Most of the description is not useful, missing, and/or contains errors.</td>
<td>The entire description is not useful and/or contains errors.</td>
<td>The solution does not include a description and it is necessary for this problem / solver.</td>
<td>A description is not necessary for this problem. (i.e., it is given in the problem statement)</td>
<td>A description is not necessary for this solver.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHYSICS APPROACH</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>NA(Problem)</th>
<th>NA(Solver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The physics approach is appropriate and complete.</td>
<td>The physics approach contains minor omissions or errors.</td>
<td>Some concepts and principles of the physics approach are missing and/or inappropriate.</td>
<td>Most of the physics approach is missing and/or inappropriate.</td>
<td>All of the chosen concepts and principles are inappropriate.</td>
<td>The solution does not indicate an approach, and it is necessary for this problem / solver.</td>
<td>An explicit physics approach is not necessary for this problem. (i.e., it is given in the problem)</td>
<td>An explicit physics approach is not necessary for this solver.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPECIFIC APPLICATION OF PHYSICS</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>NA(Problem)</th>
<th>NA(Solver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The specific application of physics is appropriate and complete.</td>
<td>The specific application of physics contains minor omissions or errors.</td>
<td>Parts of the specific application of physics are missing and/or contain errors.</td>
<td>Most of the specific application of physics is missing and/or contains errors.</td>
<td>The entire specific application of physics is inappropriate and/or contains errors.</td>
<td>The solution does not indicate an application of physics and it is necessary.</td>
<td>Specific application of physics is not necessary for this problem.</td>
<td>Specific application of physics is not necessary for this solver.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATHEMATICAL PROCEDURES</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>NA(Problem)</th>
<th>NA(Solver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The mathematical procedures are appropriate and complete.</td>
<td>Appropriate mathematical procedures are used with minor omissions or errors.</td>
<td>Parts of the mathematical procedures are missing and/or contain errors.</td>
<td>Most of the mathematical procedures are missing and/or contain errors.</td>
<td>All mathematical procedures are inappropriate and/or contain errors.</td>
<td>There is no evidence of mathematical procedures or they are necessary.</td>
<td>Mathematical procedures are not necessary for this problem or are very simple.</td>
<td>Mathematical procedures are not necessary for this solver.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOGICAL PROGRESSION</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>NA(Problem)</th>
<th>NA(Solver)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The entire problem solution is clear, focused, and logically connected.</td>
<td>The solution is unclear, unfocused, and/or inconsistent.</td>
<td>Parts of the solution are unclear, unfocused, and/or inconsistent.</td>
<td>Most of the solution parts are unclear, unfocused, and/or inconsistent.</td>
<td>The entire solution is unclear, unfocused, and/or inconsistent.</td>
<td>There is no evidence of logical progression, and it is necessary.</td>
<td>Logical progression is not necessary for this problem. (i.e., one-step)</td>
<td>Logical progression is not necessary for this solver.</td>
<td></td>
</tr>
</tbody>
</table>
\[ \frac{V^2}{R} = a = \frac{F}{m} \quad \frac{2\pi R}{T} = V \]

\[ a = \left( \frac{2\pi R}{T} \right)^2 = \frac{4\pi^2 R}{T^2} \]

\[ V = \sqrt{Ra} \]

\[ y = y_0 + \sqrt{\frac{a^2}{2}} + \frac{a^2}{2} \]

\[ = 0.65 + \sqrt{a_0^2} + \frac{a_1^2}{2} \]

\[ V^2 - v_0^2 = -2g \Delta y \]

\[ v_0 = \sqrt{2g \Delta y} = \sqrt{Ra} \]

\[ \frac{2g \Delta y}{R} = a = \frac{F}{m} \]

\[ F = \frac{2mg \Delta y}{R} = \frac{2 \cdot 18 \cdot (23 - 0.65)}{0.65} = 1237.846 N \]
Find velocity to reach height (Free Fall)

\[ v_f^2 - v_i^2 = 2a(y - y_0) \]
\[ a = \frac{2(y_f - y)}{t} \]
\[ 0 = v_f^2 - 2(g)(h-R) \]
\[ v_f = \sqrt{2g(h-R)} \]
\[ = \sqrt{2 \cdot 9.8 \cdot 2.3 \cdot 0.65} \ m = m/s \]
\[ = 20.9 \ m/s \]

It can’t be that \( v_f = v_i \) but I don’t know how to relate them. If \( v_f = v_i \), then:

Find force

\[ \Sigma F = m \ddot{a} \]
\[ T - mg = ma \]
\[ N + \frac{m}{\dot{a}} \cdot \frac{m \dot{a}^2}{a} = N \]
\[ T = mg + \frac{mv_i^2}{a} = 18N + \frac{18N}{9.8} \cdot \left(20.9^{2}\right) \]

force exerted by me = 1256N

Looks large, but stone needs to go up for
\[ V^2 = 2gh \]
\[ F - mg = \frac{m2gh}{R} \]
\[ F = 18 + \frac{2 \times 18 \times 23}{0.65} = 1292 \text{ N} \]
Comparing the Research Based Hidden Curriculum to the Instructor Hidden Curriculum – Do They Match?

Andy Mason
University of Minnesota
in absentia
Categorized cards (by interviewee)

- **OVERALL APPROACH**
  - Translating English statements into physics equations
  - Break the problem into steps

- **PROCEDURAL**
  - Draw vector diagrams
  - Substitutes to get answer

- **UNDERSTAND PHYSICS**
  - Knowing conservation of energy

- **MATURITY**
  - Recognize when something is missing
  - Comment on result
Your Categories
## Sample professor, matching

<table>
<thead>
<tr>
<th>Category</th>
<th>Useful Description</th>
<th>Physics Approach</th>
<th>Specific Application</th>
<th>Math procedure</th>
<th>Logical Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More relationships needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performing different steps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defining variables &amp; coordinate syst</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start solution looking for relationships that involve what you look for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realized different way to solve problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Sample professor, modeling matching

<table>
<thead>
<tr>
<th>Category</th>
<th>Useful Description</th>
<th>Physics Approach</th>
<th>Specific Application</th>
<th>Math procedure</th>
<th>Logical Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Math</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>More relationships needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Performing different steps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Defining variables &amp; coordinate syst</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start solution looking for relationships that involve what you look for</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Realized different way to solve problem</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Read</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Use your categories to match

<table>
<thead>
<tr>
<th>Your Categories</th>
<th>Useful Description</th>
<th>Physics Approach</th>
<th>Specific Application</th>
<th>Math Procedure</th>
<th>Logical Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How well did your categories which emerged from the “Instructor Solutions” artifact match to research based categories?

The extent to which they did indicates an overlap in two types of hidden curriculum
30 physics faculty
Equally divided between
- Research university
- PU state university
- PU private college
- Community college

90% Inter-rater reliability
How well did the overlap of the research based hidden curriculum and your hidden curriculum match with student performance represented by your rating of the student solution?

This was just a brief illustration of using interview tools for faculty and research validated rubrics to assess student performance to expose the various aspects of the hidden curriculum.

The extent to which all of the various hidden curriculums are aligned and exposed makes the learning and teaching experience more effective and less frustrating.

Thank you