Instructors’ Beliefs About Teaching Using Example Problem Solutions*

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Outline

1. Introduce teaching concept map
2. Use the teaching concept map develop hypotheses about how physics instructors:
   • Decide what types of Example Problem Solutions use
   • View their role in managing student use of Example Problem Solutions
3. Develop hypotheses about what features of expertise physics instructors value in example problem solutions?
Main Concept Map – Learning of Problem Solving

- SOME COLLEGE STUDENTS can learn how to solve physics problems if they engage in learning activities or of (Path A&B) of (Path C) affects how they working on (Path A&B) looking/listening on (Path C) appropriate problems then using (Path B) to (Path A) to appropriate example solutions/lecture can be to individualized responses can be to get the appropriate knowledge to
Main Concept Map – Teaching and Learning of Problem Solving
Management of Student Use of Example Problem Solutions (EPS)

• All six instructors described their management of student use of EPS as:
  • Assigning test or homework problems for students to work on and then provide EPS (path B – working and comparing)
  • Working EPS on the board during lecture (path C -- looking)
Management of EPS (path B)

- Suggesting/Assigning HW problems (RU1, RU2, RU3, RU4, RU6) by
- Having tests/ quizzes (RU1, RU2, RU3, RU4, RU5, RU6) and then
- Providing written solutions (RU1, RU2, RU3, RU4, RU5, RU6) by
  - PERFORM SPECIFIC TECHNIQUES (RU5)
  - APPROACHING A PROBLEM (RU5)
    - Students can see where they made a mistake and learn from my solution (RU2, RU3, RU4, RU5, RU6)

Too much work (RU2)

but I don't do it because

might be a good idea to ask the student to turn in a corrected version of the test (RU2)

Management of EPS (path B)

- Student learning activities of
- Working on
- Appropriate problems then using
  - Feedback of example problem solutions to get the
    - Appropriate knowledge
      - Which is helpful because
        - Helps with
          - Which is
            - Helps with
Management of EPS (path C)

- management of student learning activities by looking/listening to Appropriate Example Solutions/Lecture to get the appropriate knowledge.

- Allocating class time (RU1, RU2, RU3, RU4, RU5, RU6) to instructor solving problems in lecture (RU1, RU2, RU3, RU4, RU5, RU6).

- Appropriate Example Solutions/Lecture helps with UNDERSTANDING PHYSICS (RU4, RU6) which is helps with MONITORING PERFORMANCE (RU2, RU6) which is helps with MONITORING PERFORMANCE (RU2, RU6) and demonstrating aspects of MONITORING PERFORMANCE (RU2, RU6). Illustrating how principles or formulas are used (RU2, RU4, RU6).
Management of Student Use of Example Problem Solutions

• All six instructors described their management as:
  • Assigning test or homework problems for students to work on and then provide written solutions (path B – working and comparing)
    • Instructors think that students will learn by comparing these EPS to their test/HW solutions – but, they don’t believe students do this
    • Instructors don’t attempt to manage the situation further
  • Working example problems (that students have not previously seen) on the board during lecture (path C – looking)
    • Instructors don’t talk much about what students do in this situation or how this leads to learning
    • Instructors don’t attempt to manage the situation further
"Bare-Bones Solution"

The tension does no work.

Conservation of energy between point A and B:

\[ \frac{1}{2} m v_A^2 = mgh \]

\[ v_A^2 = 2gh \]

At point A, Newton’s 2nd Law gives us:

\[ T \hat{r} - w = ma \]

\[ T - w = m v_A^2 / R \]

\[ T = 18_N + 2 \times 18_N \times 23_m / 65_m = 1292_N \]
“Emphasis on Details”

Each step explicitly written and goal clearly stated

Include clarifying comments

Instructor solution II

\[
\begin{align*}
\text{Known} & : \begin{cases}
    w = 18 \text{N} = \text{weight of stone} \\
    R = 0.65 \text{m} \\
    h = 23 \text{m} \\
    v_r = 0 = \text{velocity at top} \\
    v_t = ? = \text{velocity at release} \\
    v_b = ? = \text{velocity at bottom} \\
    \text{force my hand exerts} = F = ?
\end{cases} \\
\text{Unknown} & : \begin{cases}
    E_i = E_f \\
    E_{\text{release}} = E_{\text{top}} \\
    \text{PE}_{\text{release}} + \text{KE}_{\text{release}} = \text{PE}_{\text{top}} + \text{KE}_{\text{top}} \\
    m g R + \frac{1}{2} m v_r^2 = m g h + \frac{1}{2} m v_t^2 \\
    v_t^2 = 2 g (h - R)
\end{cases}
\]

Step 1) Find \( v_t \) needed to reach \( h \)

\[
E_i = E_f \\
E_{\text{release}} = E_{\text{top}} \\
\text{PE}_{\text{release}} + \text{KE}_{\text{release}} = \text{PE}_{\text{top}} + \text{KE}_{\text{top}} \\
m g R + \frac{1}{2} m v_r^2 = m g h + \frac{1}{2} m v_t^2 \\
v_t^2 = 2 g (h - R)
\]

Using \( v_t \) from above:

\[
v_t = \sqrt{2 g (h - R)}
\]

Step 2) Find \( v_b \) needed to have \( v_t \) at release

\[
E_{\text{bottom}} = E_{\text{release}} \\
\text{PE}_{\text{bottom}} + \text{KE}_{\text{bottom}} = \text{PE}_{\text{release}} + \text{KE}_{\text{release}} \\
m g O + \frac{1}{2} m v_t^2 = m g R + \frac{1}{2} m v_b^2 \\
\]

Using \( v_t \) from above:

\[
v_b = \sqrt{2 g h}
\]

Step 3) Find \( T_b \), tension at bottom, needed for stone to have \( v_b \) at bottom

\[
\sum F = m \ddot{a} \\
\sum F_c = m \ddot{a}_c \\
T_b - w = m v_b^2 / R \\
\]

Using \( v_b \) from above:

\[
T_b - w = 2 m g h / R \]

To relate the forces to velocity we can look at the radial component, and use \( a_r = v^2 / R \).

\[
\begin{align*}
T_b = w & + 2 w h / R = 18 + 2 \times 23 / 65 = 1292 \text{N}
\end{align*}
\]

\( T_b \) equals \( F \), the force my hand exerts, for a massless string.

Conservation of energy for the stone-earth system, since no external forces.

Note: you could also choose other systems.

KE of earth estimated to be \( O \)

You could also use kinematics to find \( v_r \).

Conservation of energy for the stone-earth system.

Since \( T_A \) in circular path, \( T \) does no work.
“Emphasis on Reasoning”

Restating the question in physics terms

Planning the solution – including reasoning for each step

Starts from the target quantity (Tension)

Evaluation of final answer
Providing Resources of Example Problem Solutions

• All 6 instructors:
  • Distinguish between:
    • less detailed solution (IS1)
    • more detailed solutions (IS2, IS3)
  • Favored using solutions more detailed than IS1

• 4 of the 6 instructors:
  • Said that their solutions were similar to IS1
## Factors Affecting an Instructor’s Choice of EPS

<table>
<thead>
<tr>
<th>How will it affect student learning?</th>
<th>Less Detailed (IS1)</th>
<th>More Detailed (IS2, IS3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students who were not able to do the problem might not be able to understand the solution (RU2)</td>
<td>Makes it clear what is happening so students who had trouble can understand (RU1, RU2, RU3, RU4, RU5, RU6)</td>
<td></td>
</tr>
<tr>
<td>• Makes it clear what is happening so students who had trouble can understand (RU1, RU2, RU3, RU4, RU5, RU6)</td>
<td>• Can confuse students by discussing complications that some will not think of (RU3, RU4, RU6)</td>
<td></td>
</tr>
<tr>
<td>Will students use it?</td>
<td>Makes the solution seem easier so students might read it (RU1, RU6)</td>
<td>Can scare off students by having too many steps (RU1, RU2, RU3, RU6)</td>
</tr>
<tr>
<td>• Easy to write or find in solution manual (RU2, RU4, RU5, RU6)</td>
<td>• I’m not good at spelling things out in detail like that (RU4)</td>
<td></td>
</tr>
<tr>
<td>How hard is it to create?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What Types of Details do Instructors Prefer?

5 of the 6 instructors favored IS3 (over IS2)

<table>
<thead>
<tr>
<th>IS2 (Emphasis on Details)</th>
<th>IS3 (Emphasis on Reasoning)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clear Steps (RU2)</td>
<td>• Plans before execution (RU1, RU3, RU4)</td>
</tr>
<tr>
<td>• Starts from known quantity (RU1)</td>
<td>• Evaluates answer (RU3, RU6)</td>
</tr>
<tr>
<td>• Jumps right in with calculations (RU1)</td>
<td>• Explains reasoning (RU5, RU6)</td>
</tr>
<tr>
<td>• Systematic approach implies that there is a standard way to do problems (RU4)</td>
<td>• Starts from target quantity (RU1)</td>
</tr>
</tbody>
</table>
Instructor Solution 3 Has Features of Expert Problem Solving

Features of Expert Problem Solving in IS3:

<table>
<thead>
<tr>
<th>Feature</th>
<th>RU1</th>
<th>RU2</th>
<th>RU3</th>
<th>RU4</th>
<th>RU5</th>
<th>RU6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Restates problem in physics terms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Starts from target (goal) quantity</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Plans first then executes</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>4. Evaluates answer</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

All features of expertise noticed were described as desirable
Preliminary Hypotheses

• Faculty do little to actively manage student use of problem solutions – they simply make the solutions available for students.

• Faculty consider three factors when deciding what types of solutions to use:
  • How will the solution affect student learning?
  • Will students use the solution?
  • How hard is it to create the solution?
Preliminary Hypotheses

• Faculty are dissatisfied with the solutions that they currently use.

• Implications: This is an opportunity for curriculum developers to influence the current practice by developing solutions that:
  • Make reasoning clear (especially by showing planning)
  • But are not
    • Too complicated → Confuse students
    • Too long → Scare students
Preliminary Hypotheses

• Faculty value features of expertise that they recognize in problem solutions.

• Faculty do not appear to recognize all features of expertise in problem solutions.
  
  • Many noticed planning before execution
  
  • None noticed restating the problem in physics terms
  
  • Some noticed:
    • starting from target quantity
    • evaluating answer

• Implications: Faculty may be unable to model features of expert problem solving in their problem solutions.
Next Steps

☑️ Use 6 RU interviews to generate hypotheses

Use remaining 24 interviews to test/refine hypotheses

Use written questionnaire to expand to a larger national sample

Develop a map of instructors’ values to guide curriculum developers
The End

For more information, visit our web site at:

http://www.physics.umn.edu/groups/physed/
Refer to the free-body diagram below. As Tarzan (of mass $m$) swings from point $A$ to point $B$ (the bottom of the swing), we have $\Delta K + \Delta U = 0$, i.e.,

$$\frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2 + mgh = 0,$$

which we solve for $v_B$:

$$v_B^2 = v_A^2 + 2gh = 2gh = (2)(3.2\text{ m})g = (6.4\text{ m})g.$$

At point $B$, we may apply Newton’s second law to Tarzan to obtain the equation for the tension $T$ in the vine:

$$T - mg = \frac{mv_B^2}{R},$$

which gives

$$T = mg + \frac{mv_B^2}{R} = mg + \frac{m(6.4\text{ m}g)}{R} = (688\text{ N})\left(1 + \frac{6.4\text{ m}}{18\text{ m}}\right) = 930\text{ N}.$$

Since $T < 950\text{ N}$, the vine will not break after all.
Providing Resources of EPS

• 5 of the 6 instructors favored IS3 (over IS2) based on the following features:
  • Plan first, then execute (RU1, RU3, RU4)
  • Explains reasoning (RU5, RU6)
  • Evaluates answer (RU3, RU6)
  • Starts from target quantity (RU1)