Communicating like a physicist
Teaching physics representations to high school students

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CONASTA 2013
Multiple Representations in Science

- Communication
  (Learning and Sharing)

- Solving problems

“Fluency in a critical constellation of modes of disciplinary discourse may be a necessary (though not always sufficient) condition for gaining meaningful holistic access to disciplinary ways of knowing”

(Airey & Linder, 2009)

Memory can be of two main forms (Sweller, 1988);
- Working memory (limited in capacity and longevity)
- Long term memory

Cognitive load on working memory is necessary for schema formation, but may be overburdened by unnecessary chunks of information

Seery and Donnelly (2012) introduced chemistry instruction (on chemistry concepts) designed to improve learning during traditional teaching classes based on reducing in-class cognitive load.


Representational use of top and bottom scoring RRS students

› To investigate whether the designed worksheets will result in different answers* for the common questions depending on whether the worksheet focuses on physics concepts or representations.
  - *in particular we are looking for differences in representational use.
Step 1: Students were asked to complete two “test questions” which were designed to see how students used representations.
Step 2a: Students were split into two groups and asked to complete two worksheet which taught either **representations** or **concepts**.
Study Design

Step 2b: The final part of each worksheet was the “test question” repeated to allow us to compare the impact of the teaching worksheets.

Question 3:
Identify the main forces involved in this scenario pictured

What is the first thing you would do if you were asked to solve the following problem: What is the force required to move along the floor the box with a mass of 80kg if the coefficient of static friction was 0.4?
Would you:
(a) Write out the appropriate Newton’s Law
(b) Draw a free body diagram

The first thing I would do is ______________
Step 2b: The final part of each worksheet was the “test question” repeated to allow us to compare the impact of the teaching worksheets.

The process was repeated with a second set of worksheets focussing on difference concepts and representations.
Results – School A (C=14, R=18)

Question 3:
Identify the main forces involved in this scenario pictured.

Effect of concepts (C) or representations (R) worksheets

- Using the word "Tension"
- Describing the Normal force
- Box Focus
What is the first thing you would do if you were asked to solve the following problem: What is the force required to move along the floor the box with a mass of 80kg if the coefficient of static friction was 0.4?

Would you:
(a) Write out the appropriate Newton’s Law
(b) Draw a free body diagram

Part 2

Draw a free body diagram first

<table>
<thead>
<tr>
<th></th>
<th>Pre Worksheet</th>
<th>Post Worksheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>R</td>
<td>18</td>
<td>10</td>
</tr>
</tbody>
</table>
Question 3:
Write out a plan (i.e. what steps you would take) in the box below for how you would solve the following problem: A car is travelling along a level icy road with no traction (that is, no friction) and comes to a rise 20m long at an inclination of 25 degrees. What minimum speed does the car need to be going at the bottom of the slope to reach the top?
Discussion – School A (C=14, R=18)

› There were clear changes in the answers from students doing the conceptual worksheets
  - The conceptual worksheets are effective

› There was little change from students doing the representational worksheets
  - The representations worksheets need to be clearer and simpler

› Some areas where change was expected did not produce any differences post worksheets
  - The “test questions” need to be changed slightly
Results – School B (C=6, R=7)

Question 3: Identify the main forces involved in this scenario pictured.

![Image of a person pulling on a rope with a lever]

- **Using the word "Tension"**
  - Pre Worksheet: 3 students
  - Post Worksheet: 1 student

- **Describing the Normal force**
  - Pre Worksheet: 2 students
  - Post Worksheet: 2 students
Results – School B (C=6, R=7)

Question 3:
Identify the main forces involved in this scenario pictured

This was something deliberately targeted.
Write out the things you would do to solve the following problem: What is the force required to move along the floor the box with a mass of 80kg if the coefficient of static friction was 0.4?
Solve the following problem: For a roller coaster to make it around a vertical loop (see diagram) it must be going at a minimum speed based on the loop. If the loop is a circle with radius 15 m, how fast must the roller coaster car be going at the bottom of the loop to make it around the whole loop?

In solving the problem as you go, work out how to solve it:
There were clear changes in the answers from students doing the either worksheets
- Both worksheets are effective

There were clear differences between the representations present in students answers depending on which worksheet they were given
- The questions are sensitive enough to pick up the difference
How can students get the most out of physics?

1 – Drawing a diagram helps

2 – Representations on their own are often less effective than representations in combination. If you can explain the equations or diagrams you draw, you are more likely to be able to generate a correct answer.

3 – When you read material, such as your text book, don’t just read the words but connect the words with the pictures, diagrams, equations and flow charts that are on the page.