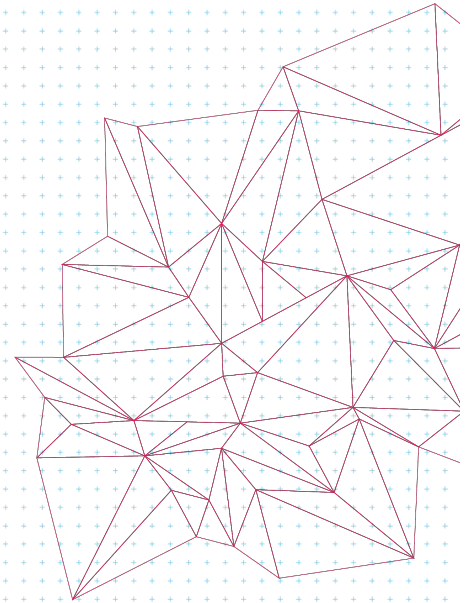


Developing reasoning and metacognitive skills through reflective lab reports

Jasmina Lazendic-Galloway

TU/e innovation Space, Eindhoven University of Technology
j.lazendic.galloway@tue.nl

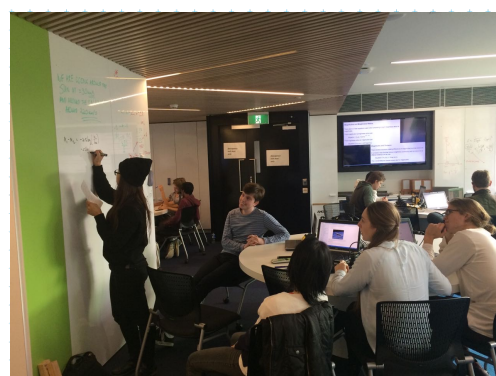
School of Physics and Astronomy, Monash University



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Context: PACE (Physics and Astronomy Collaborative-learning Environment) studios at Monash built in 2014



- Elective 1st year unit, mainly engineering students (~75%), enrolment around 200 students
- Covers: Newtonian mechanics, Electromagnetism (previously Waves & Optics), and Quantum Mechanics

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Usual set-up of the courses:

Lectures – information transfer

Tutorials – working on problem sets related to concepts from the lectures

Labs – learning about experimental side of physics – and uncertainties, uncertainties, uncertainties



Assessed via the mid-semester test and exam (80%)

We are assessing different skills, but the reasoning used should be the same!

Assessed via lab reports (20%)

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Novice versus Expert Problem Solvers

Novices and experts approach problems very differently. Broadly speaking, distinctions between their approaches include:

Novices...	Experts...
<ul style="list-style-type: none"> Memorize how to solve specific problems. Ex.: "Use $mgh = \frac{1}{2}mv^2$" 	<ul style="list-style-type: none"> Believe that you can solve most problems by memorizing only a few central principles. Ex.: "Use conservation of Energy"
<ul style="list-style-type: none"> Identify problems in terms of surface elements. Ex.: "This is an inclined plane problem." 	<ul style="list-style-type: none"> Identify problems using principles by which you can solve them. Ex.: "This is a friction and gravity problem."
<ul style="list-style-type: none"> Believe that most problems are too difficult for them to solve. 	<ul style="list-style-type: none"> Are confident that they can solve problems, work a long time before giving up, and do not believe that this is a waste of time.
<ul style="list-style-type: none"> Do not think about how they solve problems but instead just plow through them. 	<ul style="list-style-type: none"> Are able and willing to evaluate their own thinking.
<ul style="list-style-type: none"> Move on to the next problem without considering possible connections between them or the concepts that may inform them. 	<ul style="list-style-type: none"> After solving problems, review why the question was important, asking why the professor gave the assignment.

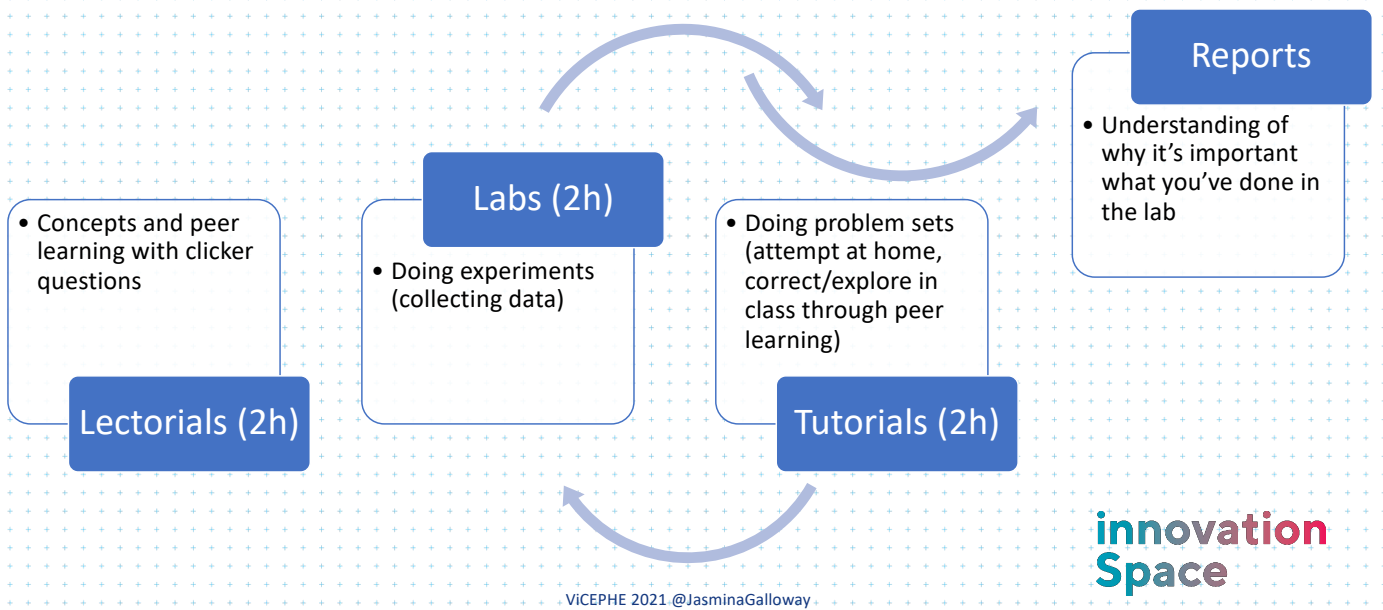
What is the issue I wanted to address:



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Setting up active learning cycle

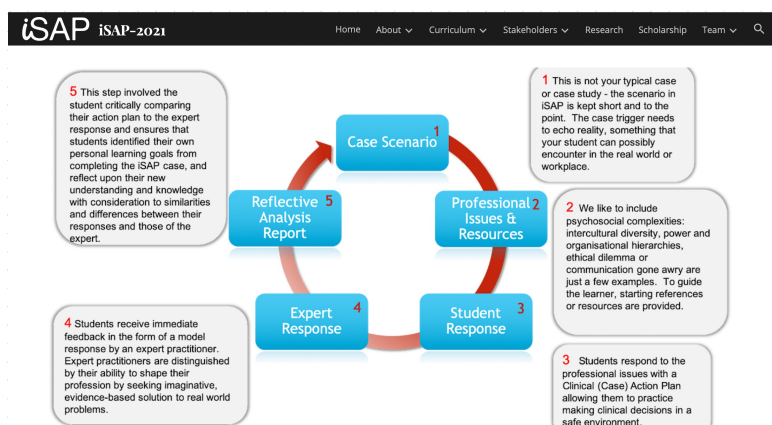


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Using dual feedback

Integrating Science and Practice (iSAP): An Interactive Case-Based Clinical Decision-Making Radiography Training Program

Williams, I., Schliephake, K., Heinrich, L. M., & Baird, M. A. (2017)



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PHS1002 Report: Rotation

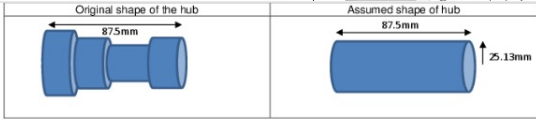
(Experimental Skills)
 Q1. Describe two ways in which you estimated/determined the moment of inertia of the disc and hub.

The moment of inertia refers to the resistance of an object to its rotational motion. This property is intrinsic to the object and is proportional to the objects mass and its distance from the center of the rotation. The disc and hub were composed of 5 cylinders which we assumed to be fill and not hollow. This means that the inertia of the disc and hub are the sums of the inertia of each individual cylinder. A cylinder has the inertia:

$$I = \frac{1}{2}mr^2$$

Whilst it was possible to determine the radius of the cylinders (by using a Vernier callipers to measure the diameter of the hub and then divide the value by 2, and using a ruler to measure the radius of the disk(which came to be 21.5 +/-0.5mm) and the mass of the disc (0.800+/-0.005kg) was provided to us, the mass of the hub was not. However, the hub is made of aluminum measurement of mass/volume, and ca cylinder can be found using the followi

Instead of calculating the volume of ev cylinders where of the same radius an cylinders. This would have affected th the cylinders of the hub differed in radi



The volume of the assumed hub came to be $1.74 \times 10^{-4} \pm 1.8 \times 10^{-7} \text{m}^3$. This meant that the approximate mass of the hub was 0.469kg which is $469 \pm 1.8 \times 10^{-3} \text{kg}$.

Now that the radii and the masses of the hub and the disk where known, the moment of inertia calculated by adding together the moment of inertia of the hub to the moment of inertia of the disk:

$$I_{total} = I_h + I_d$$

$$I_{total} = \frac{1}{2}m_h r_h^2 + \frac{1}{2}m_d r_d^2$$

$$I_{total} = \frac{1}{2} \times 0.469 \times (25.13 \times 10^{-3})^2 + \frac{1}{2} \times 0.800 \times (215 \times 10^{-3})^2$$

$$I_{total} = 1.48 \times 10^{-4} + 0.0185$$

$$I_{total} = 0.0186 \pm 1.59 \times 10^{-4} \text{kgm}^2$$

There is also a second way of calculating the moment of inertia of the disc/hub system. This was done by attaching a string to the hub and a weight at the end of the string which weighed 0.05g. By doing this we can use the Law of Conservation of Energy. The gravitational potential weight, as it falls from the hub to the table surface, is the same as the energy used in the rotation. Hence:

$$mgh = \frac{1}{2}I\omega^2$$

This can be manipulated to have inertia as the subject and so the following equation is derived:

$$I = \frac{mgt^2}{4\pi} - mr^2$$

where m = weight of the falling weight
 & r = the radius of the hub
 & t = time taken for the weight to fall

The string was wound around the hub anticlockwise, so that it would unwind clockwise, and 5 times and the average was taken.

Assignment was submitted 1
 Student cannot edit this subm
 Lab 1 Rotation Question
 Comments (0)
 Grade
 Experimental skills:

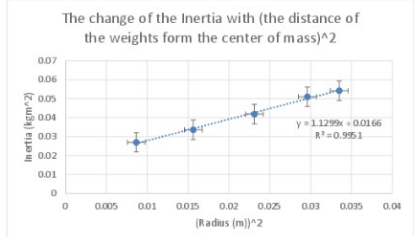
Step 1: Submit your answers

plot complete with all features (title, axes labels, error bars and line of best fit). Also state estimates for the mass of the masses attached with uncertainties. To produce a graph which would reveal the mass of the masses added to the disk, the inertia equation for the mass:

$$I_{total} = I_h + mr^2$$

$$m = \frac{I_{total} - I_h}{r^2}$$

Now that it is known how to get the mass, a graph of r^2 against the difference in inertia can be graphed. In this case the gradient of this graph will be the mass.



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Questions are "tagged":

- (Experimental Skills)**
 Q1. Describe two ways in which you estimated/determined the moment of inertia of the disc and hub.
- (Technical Analysis)**
 Q2. Describe the logic behind the plot you made to determine the mass of the masses attached to the disc. Show the plot complete with all features (title, axes labels, error bars and line of best fit). Also state estimates for the mass of the masses attached with uncertainties based on the fit results (from Excel's LINEST function).
- (Synthesizing Knowledge and Critical Thinking)**
 Q3. Why was it important that the weights be placed on the disc symmetrically?



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Step 2: Read an explanation from an “expert” and reflect:

(Technical Analysis)

Q2. Describe the logic behind the plot you made to determine the mass of the masses attached to the disc. Show the plot complete with all features (title, axes labels, error bars and line of best fit). Also state estimates for the mass of the masses attached with uncertainties based on the fit results (from Excel's LINEST function).

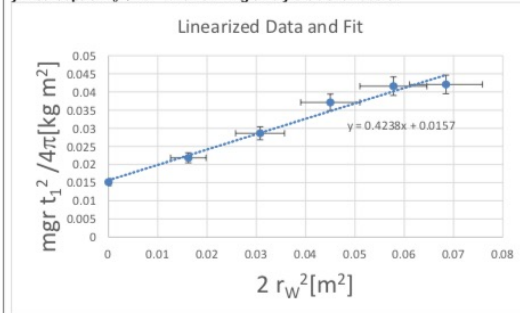
EXPERT ANSWER

Since now we would have an expression for the moment of inertia of the disc and masses as:

$$I_T = I_0 + I_w = \frac{(m g r t_1^2)}{4 \pi} - m r^2 \text{ and the masses add inertia of } I_w = 2 m_w r_w^2 \text{ we have}$$

$$I_0 + 2 m_w r_w^2 = \frac{(m g r t_1^2)}{4 \pi} - m r^2 \text{ which we can rearrange to } 2 m_w r_w^2 + I_0 + m r^2 = \frac{(m g r t_1^2)}{4 \pi}$$

Thus we can plot say $2 r_w^2$ as the x axis, and $\frac{m g h}{4 \pi} t_1^2$ as the y axis. This will be linear with a slope of m_w and a y-intercept of $I_0 + m r^2$. Performing this yields the result:



And results in linest output:

	Slope (M_w [kg])	Intercept [kg m ²]
Value	0.42	0.016
Uncertainty	0.03	0.001

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Reflection Questions:

(Experimental Skills)

Q1. How does your answer compare to the expert's? Does your answer clearly describe the details of the method including what to measure and how to then determine the moment of inertia from these quantities? Have you clearly identified variables measured and used and any assumptions made?

(Technical Analysis)

Q2. How does your answer compare to the expert's? Does your answer explain how to isolate the mass of the weights added? Have you included all elements required for the plot and remembered to use Linest to determine the line of best fit and the uncertainties? (Note: your axes may not be the same but is your plot still linear? Does the fit provide the mass of the weights in some way?)

Synthesizing Knowledge and Critical Thinking)

Q3. How does your response compare to the experts? Have you explained the physical relevance of placing the weights symmetrically?

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Step 3: Both reports are now marked

- “Tags” for each question – marked according to mastery

Q2

The estimated mass was found by calculating I_{total} using the time recorded. As $I_{\text{total}} = I_h + 2MR^2$ (As there are masses each with mass M equidistant from the centre), we could find I_h , the moment of inertia of the wheel. From there, the mass could be estimated by averaging the masses calculated for each of the five radii.

For each of the five radii, the masses found were:

- 1.5612 kg
- 0.994058 kg
- 0.914040 kg
- 0.824031 kg
- 0.734026 kg

Thus the estimated average mass was 0.99±0.56 kg.

Q3

The discs had to be placed symmetrically to avoid a jagged change in rotational velocity. This was important for accurate results.

Notify students **Save changes** **Reset** VICEPHE 2021 @JasminaGalloway

Workshop 3

Submit Report W3	-	-	
Content knowledge: spectrum	Demonstrated	Not demonstrated-Mastered	Demonstrated (218)
Content knowledge: light	Mastered	Not demonstrated-Mastered	Mastered (218)
Reasoning skills	Developing	Not demonstrated-Mastered	Demonstrated (218)
Observational skills	Mastered	Not demonstrated-Mastered	Demonstrated (218)
Synthesising Knowledge	Not demonstrated	Not demonstrated-Mastered	Demonstrated (218)
Problem Solving Skills	Mastered	Not demonstrated-Mastered	Demonstrated (218)
Workshop 3 total grade (/18)	12.00	0-18	11.65 (238)
Simple weighted mean of grades. Include empty grades.			

Workshop 4

Submit Report W4

Students can easily see the level of their mastery in Moodle gradebook

(and compare how they've done in respect to the rest of the cohort)

Rubric is simple (on purpose)

What are we looking for in the answers to reports' questions:			
Mastered	Demonstrated	Developing	Not demonstrated
Addressed all the points of Physics/Method/Interpretation, in sufficient detail, with evidence/support, and good clarity.	Addressed all the of Physics/Method/Interpretation with evidence and support, but with occasional lack of clarity, or with minor error in calculations or processing of evidence OR good answer to slightly misinterpreted question.	Neglected to provide support for comments about Physics/Method/Interpretation or missing some key ideas of the Physics/Method/Interpretation, OR good answer to totally misinterpreted question, OR decent answer to a slightly misinterpreted question.	No response OR missed the point of the question.
What are we looking for in the reflections:			
Mastered	Demonstrated	Developing	Not demonstrated
Noted similarities in concepts and did not emphasize irrelevant differences, noted differences in Physics/Method/Interpretation present in original answer or all such differences noted and understood.	Noted similarities in Physics/Method/Interpretation, but also worried about irrelevant differences, or didn't notice a small but important difference in Physics/Method/Interpretation.	Noted some similarities and differences, but didn't notice or highlight some fundamental differences in Physics/Method/Interpretation.	No response, or a response that focused only on irrelevant details of presentation instead of noticing glaring differences in Physics/Method/Interpretation.

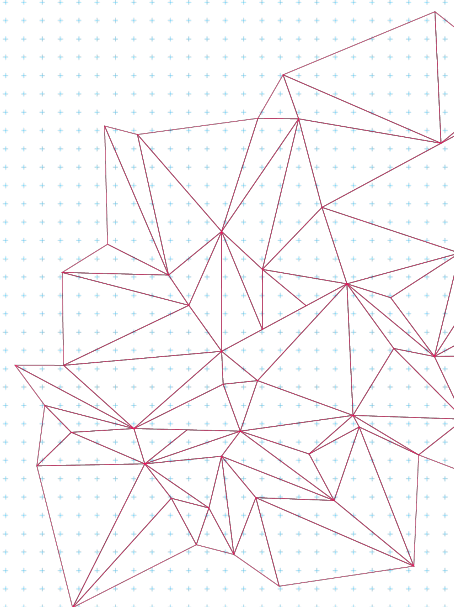
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... and dual feedback

Students are provided with dual feedback (Laurillard 2012):

- 1) their *intrinsic* feedback from the comparison, and
- 2) *external* feedback from the instructor on both their original answers, as well as their reflection



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Did it work?

Top five themes identified from student responses to open-ended survey questions:

Q1: Which aspect(s) of this unit did you find most effective?

	Old way 2016	1 st run 2017	2 nd run 2018
Number of responses/number of students (per cent)	65/195 (33%)	102/184 (55%)	153/229 (67%)
The top 5 emerging themes for Q1 - what is effective?			
Labs	15 (23%)	29 (28%)	28 (18%)
Lab reports	n/a	5 (5%)	18 (12%)
Tutorials	5 (8%)	10 (10%)	37 (24%)
Interactive lectures/lectorials	3 (5%)	6 (6%)	31 (20%)
Pre-lecture videos	n/a	13 (13%)	4 (3%)

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What did students think?

- *The feedback method is very impressive. Because we can find out **our weaknesses and strengths** in this unit.*
- *I thought it was great that a lot of our in-class assessment had a **focus on demonstrating that we were in the process of learning the material**, i.e. the answer didn't necessarily have to be correct – as long as we'd made a good effort and recognised our mistakes, we'd get a decent grade. This took the pressure off the assignments a little, thus letting us have more time to focus on learning the material.*
- *Cancel reflection reports, we are scientists not writers."*

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