Activating the student’s prior knowledge in the learning of third Newton law through a P.O.E. (“Predict-Observe-Explain”) strategy.

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Laboratory hand-on activities are traditionally used in secondary education as:

**VERIFICATION**

of the new knowledge learned in the theory class
Rethinking lab activities from the constructivism perspective

Principios de aprendizaje constructivista

Focused on student’s interest

Learning = reorganization of internal mental frameworks

Prior-Knowledge as starting point for learning

Learners play an active role in learning.

Learning occurs by interaction with environment/people.

Conflict with prior-Knowledge trigger more significant learning

Degree of potential learning depends on cognitive development

Strategy

Prediction

Observation

Explanation
Flip the order: lab activities first

Use the lab hand-on activities to introduce new scientific concepts may improve:

- Activation of prior-knowledge
- Abstract thinking
- Scientific argumentation

to enhance

significant learning
Steps of the P.O.E. strategy

- **Prediction**
  - Alternative/wrong ideas
  - Prior-Knowledges

- **Observation**
  - Experimentation
  - Scientific language
  - Critical thinking

- **Explanation**
  - Scientific argumentation
  - Scientific reasoning
  - Abstract thinking

**Counter-argumentation**
- Conceptual change
- Reorganization of internal mental framework

**New Knowledge**

**New competences**
But... **not all experiments work** to introduce new scientific concepts to the students.

It is necessary to rethink hand-on lab experiences to use the P.O.E. strategy.

**Counter-intuitive experiments work better**

- As more **counterintuitive** the experiment is
- higher conflict with the prior knowledge
- more internal mental rearrangement
- More abstract thinking & scientific argumentation are needed
- Higher significant learning
Newton's Laws of Motion

1st Law
A body in motion remains in motion or a body at rest remains at rest, unless acted upon by a force.

2nd Law
Force equals mass times acceleration: \( F = m \times a \)

3rd Law
For every action, there is an equal and opposite reaction.
On the teaching of **Newton’s Laws** using a P.O.E. strategy

**First law**

*Every body remains in a state of rest or uniform motion unless acted upon by a net external force.*

**Second law**

*The amount of acceleration of a body is proportional to the acting force and inversely proportional to the mass of the body.\[ F=ma \]*

**Third law**

*For every action there is an equal but opposite reaction. If an object A exerts a force on object B, then object B will exert an equal but opposite force on object A.*
The goal is to detect alternative ideas and misconceptions in the Prior Knowledge of students
## Predictions related with experiment 1

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does the scale show the same, more, or less weight if you step on it with one foot compared to stepping on it with both?</td>
</tr>
<tr>
<td>2</td>
<td>If you step on the scale on the Moon, would it indicate more, less, or the same weight?</td>
</tr>
<tr>
<td>3</td>
<td>Would your mass on the Moon be the same, more, or less than on Earth?</td>
</tr>
<tr>
<td>4</td>
<td>Does the scale show the same, more, or less weight if you lean on a friend?</td>
</tr>
<tr>
<td>5</td>
<td>If you stand on tiptoes on the scale, does it always show the same weight?</td>
</tr>
</tbody>
</table>

This is the important question to cover the important prediction.

This is the important question.
PREDICTION step in the teaching of Newton’s law

<table>
<thead>
<tr>
<th>Predictions related with experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Which way would a sailboat move with the wind against it if the sail is positioned as shown by the green line?</td>
</tr>
<tr>
<td>a) It would approach point B</td>
</tr>
<tr>
<td>b) It would approach point A</td>
</tr>
<tr>
<td>c) None of the above</td>
</tr>
<tr>
<td><img src="sailboat.png" alt="Diagram of sailboat and wind" /></td>
</tr>
</tbody>
</table>

| 2. If on a day with little wind, a giant fan located at the back of the boat is turned on, sending air towards the sail, how does the boat move? |
| a) It would approach point B         |
| b) It would approach point A         |
| c) None of the above                |
| ![Diagram of fan and sailboat](fan.png) |

*Table 2. Questions related with experiment 2. Question #2 was the relevant question to test through P.O.E. strategy.*
OBSERVATION step in the teaching of Newton’s law
EXPLANATION step in the teaching of Newton´s law
RESULTS OF A PILOT EXPERIENCE with MASTER´s students

Did the students predict correctly the experiments 1?
- 95% right
- 5% wrong

Did the students find useful experiment to learn Newton´s laws?
- 42% yes
- 58% no

Which experiments do students consider to produce a more significant learning of the Newton’s laws?
- 79% scale
- 21% sailship
Future Work

1. Test the P.O.E. with secondary students and large statistics.

2. Design new counter-intuitive experiments to introduce other scientific concepts in the curriculum (center of mass, inertia momentum, flotability...).

1. Introduce the use of visual argumentation tools as “Gowin’s uve” and test their efficiency to enhance scientific reasoning in secondary students.
Thank you for your attention

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