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Application of the Theory of Model-Based Learning and Teaching to an Experimental Stoichiometry Class

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Introduction

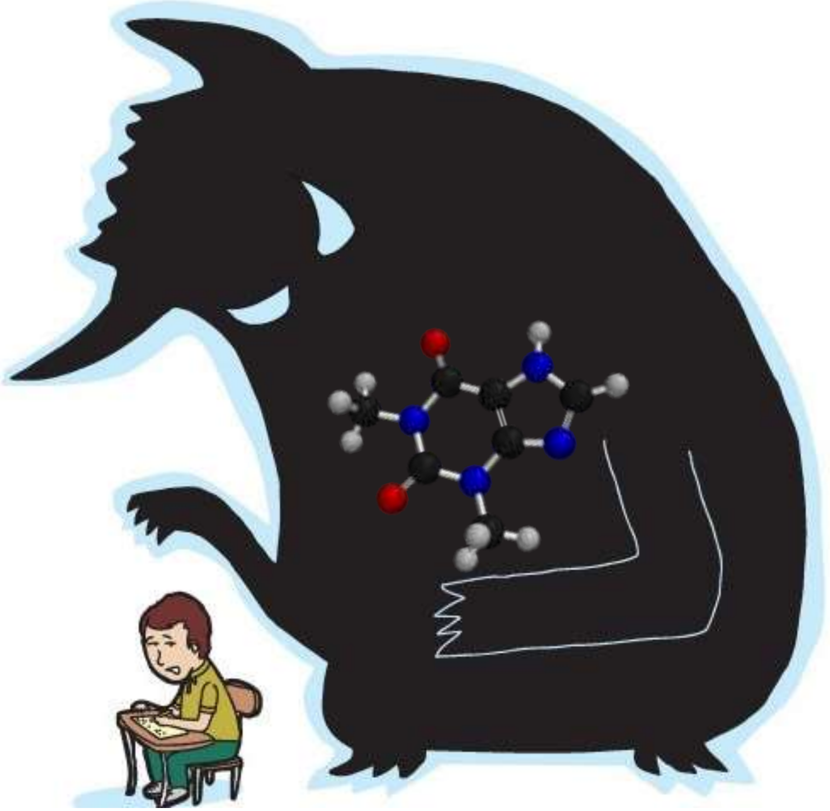
Difficulties with the "Chemistry Monster"

1) The chemistry teacher was not the most ideal to teach the subject and he/she did not motivate us.

Méndez, D. (2015). *Educación XX1, 18*(2), 215-235 t

2) This is a subject where you have to think.

Gómez, M. Á., Pozo, J. I., Gutiérrez, M. S. (2004). *Educación Química, 15*(3), 198-209.



3) Why are we learning this? Where am I going to use it?.

Chamizo, J. A. (1995). *Educación Química, 8*(2), 118-124.

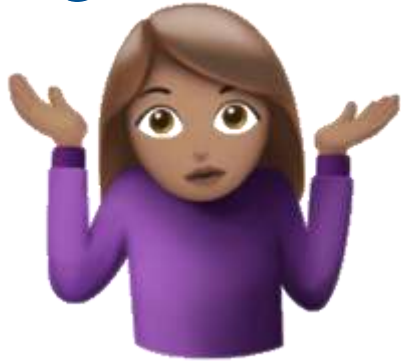
Introduction

Introduction

And which one are the "difficulties" in stoichiometry?

1) Even when the students do the calculations, they do it mechanically, not being conscious of what they are doing.
They do not reflect, so the cognitive process is soft.

2) The stoichiometry labs are recipes. "If is written there, surely is going to work". So, they do not present a challenge for the students.



Introduction

Framework

How to solve this difficulties?

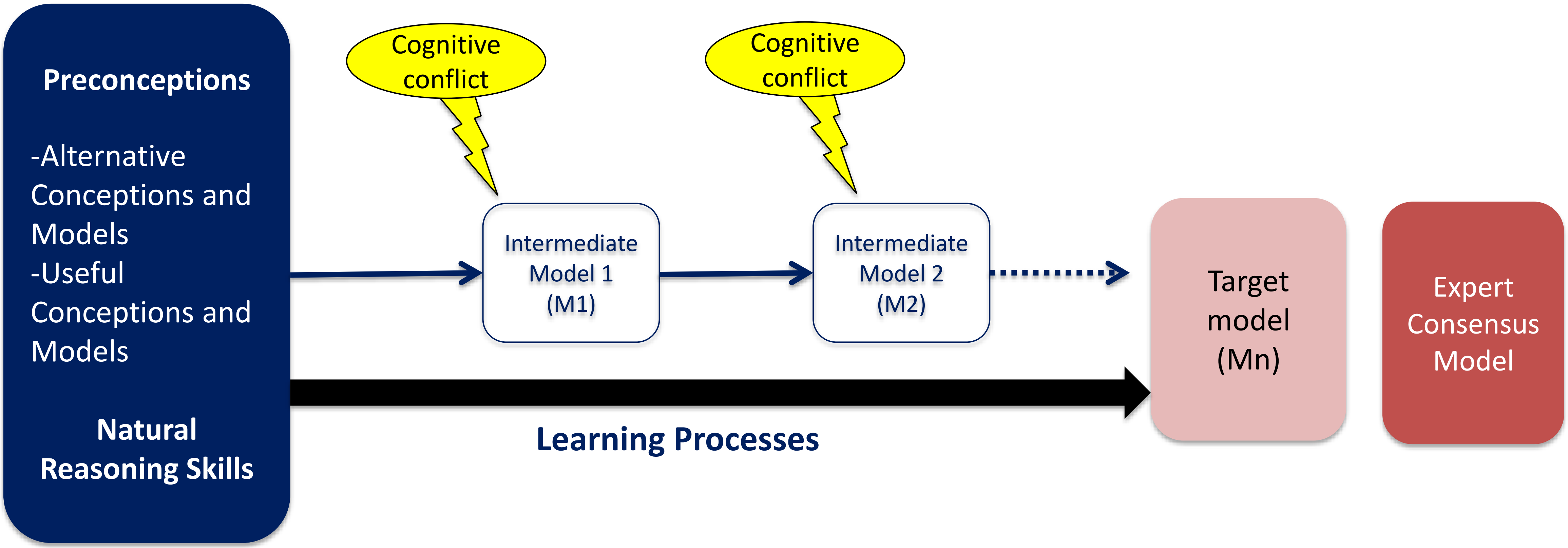
María C. Nunez-Oviedo

John C. Clement

Framework

Framework

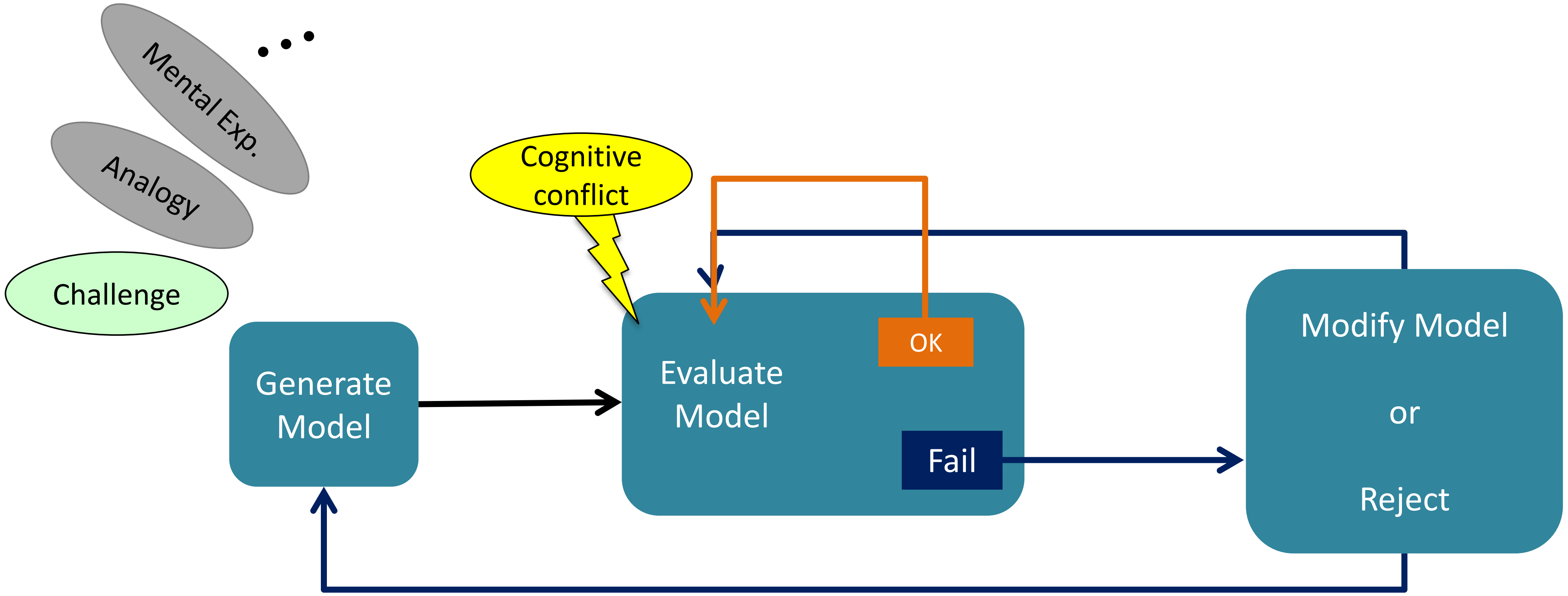
Student's Learning Pathway



Framework

Framework

GEM (Generation, Evaluation, Modification) cycles

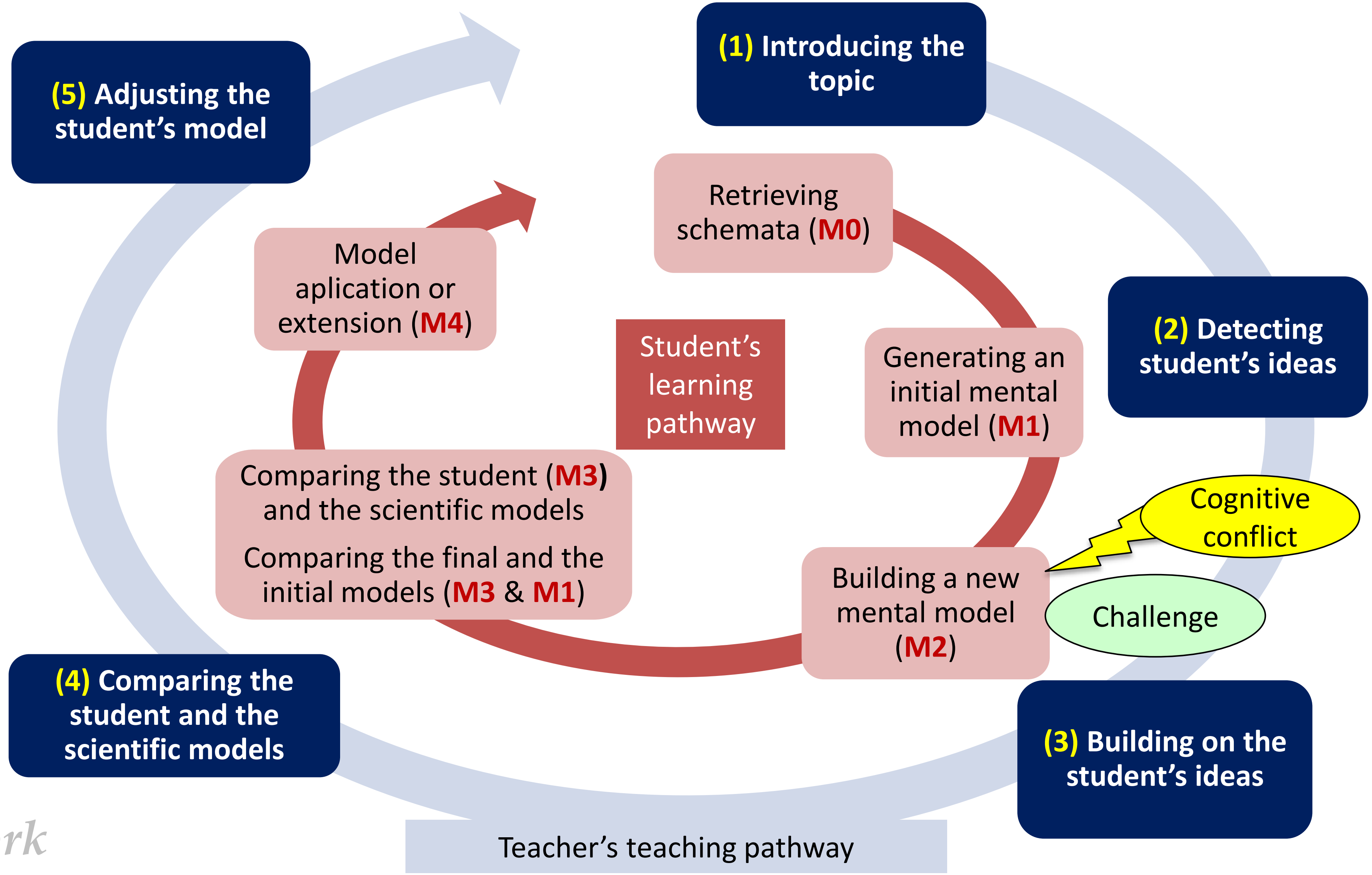


Nunez-Oviedo, M.; Clement, J. J. (2019). *Large scale scientific modeling practices that can organize science instruction at the unit and lesson levels*. Frontiers in Education 68 (4) 1-22.

Framework

Framework

Co-construction of knowledge cycle

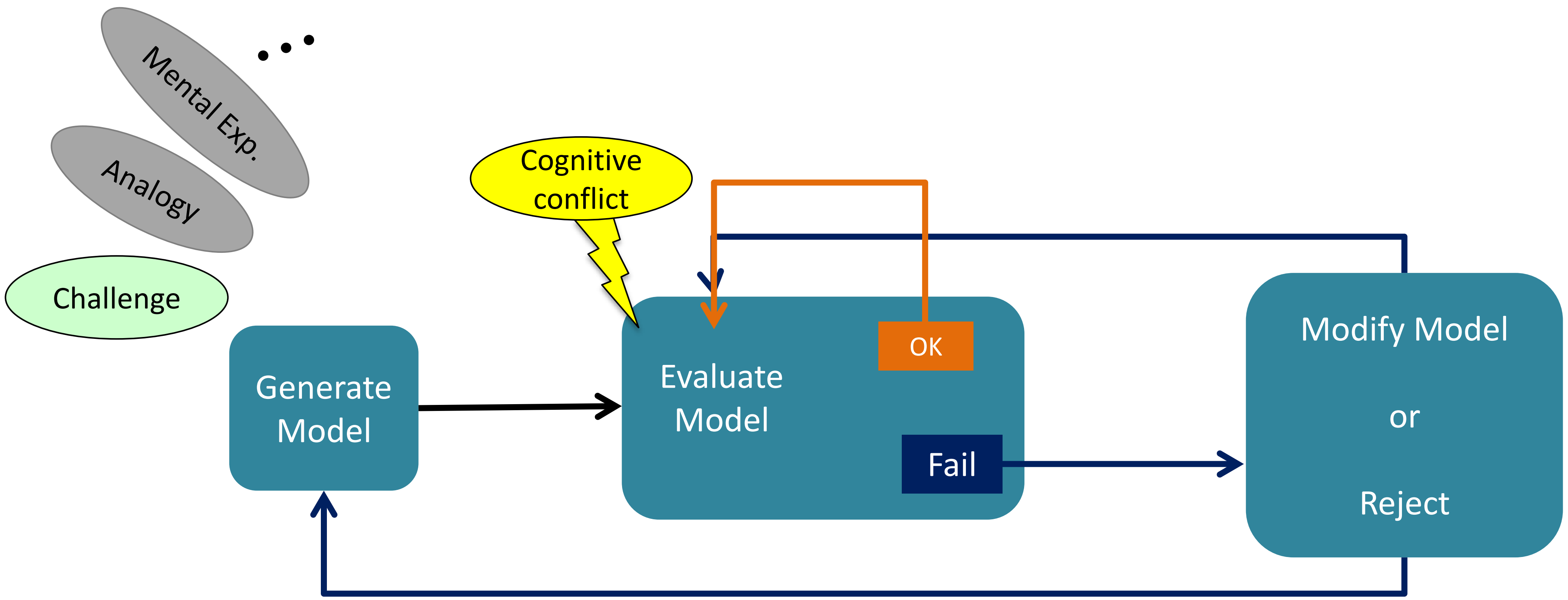


Nunez-Oviedo, M.; Clement, J. J. (2019)

Framework

Framework

GEM (Generation, Evaluation, Modification) cycles



Nunez-Oviedo, M.; Clement, J. J. (2019). *Large scale scientific modeling practices that can organize science instruction at the unit and lesson levels*. Frontiers in Education 68 (4) 1-22.

Framework

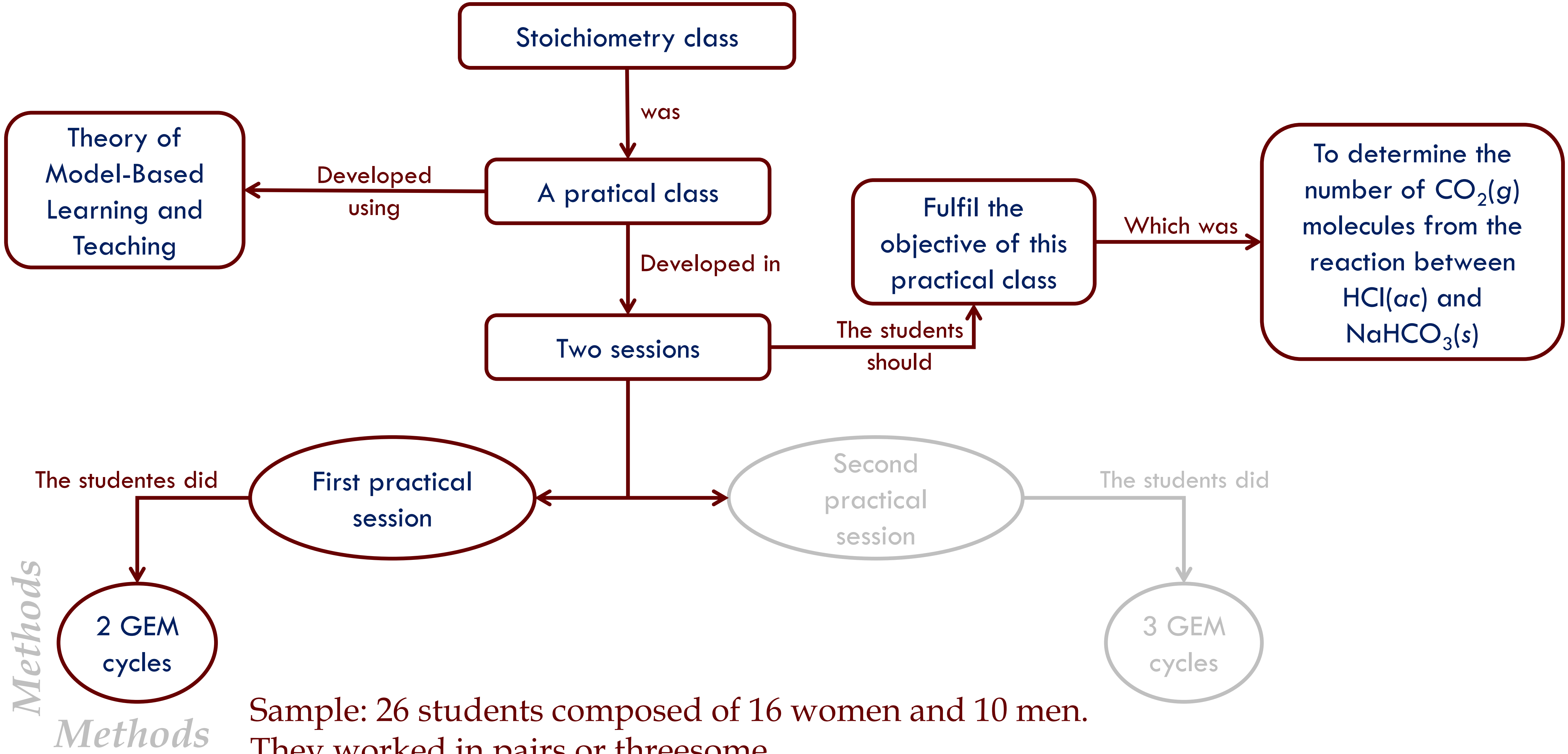
Framework

Objective

To identify and describe teacher-student GEM cycles while experimenting

Methods

Overview and sample characteristics

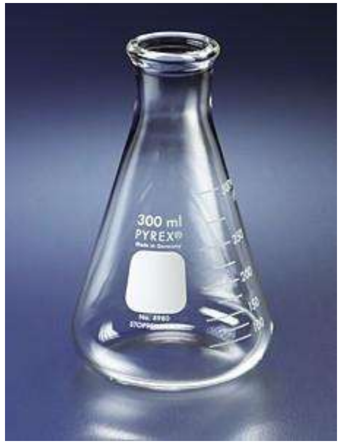


Sample: 26 students composed of 16 women and 10 men.
They worked in pairs or threesome.

Experimental part

Reactants:
- 25 mL of 1.0 mol L^{-1} HCl(*ac*)
- 1 to 5 g of $NaHCO_3$(*s*)
- A piece of tissue

Materials:
- Erlenmeyer flask
- Balloon or surgical glove
- Sticky tape

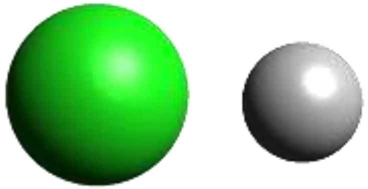


Methods

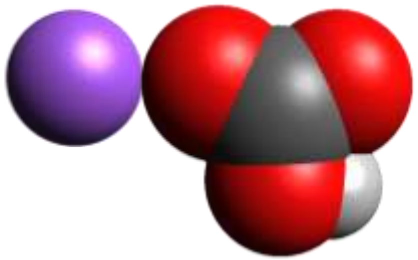
Methods

Challenge: How could you determine the number of CO_2(*g*) molecules produced? Draw a system and mount it.

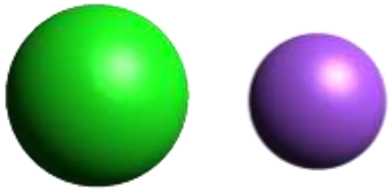
Chemical equiation and chemical reaction



$HCl(ac)$
Hydrochloric acid



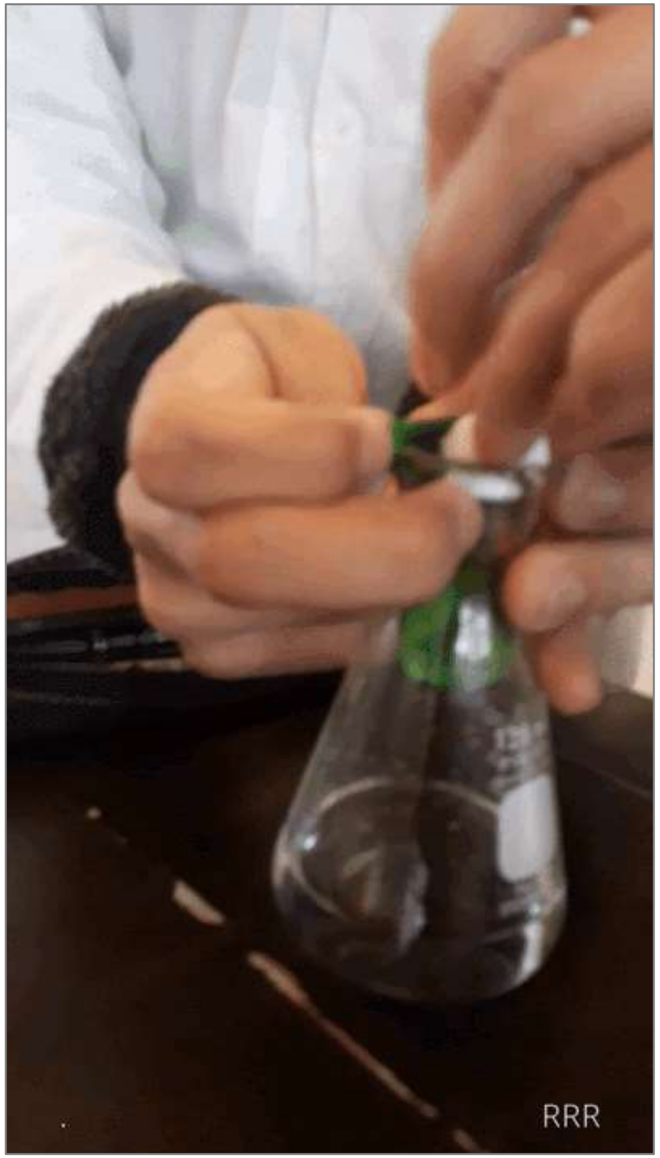
$NaHCO_3(s)$
Sodium bicarbonate



$NaCl(ac)$
Sodium cloride

$H_2O(l)$
Water

$CO_2(g)$
Carbon dioxide

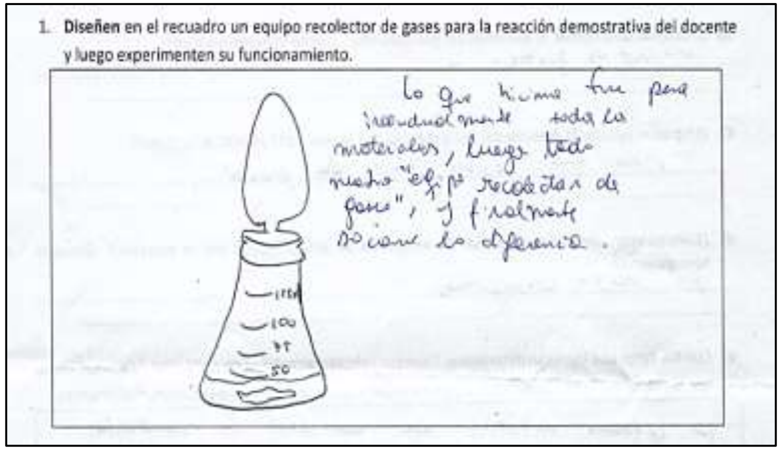


Results

1st GEM cycle: Mass difference by weighing

Generation

The students hope to obtain the mass of CO_2(g) produced by subtraction: the mass of the materials + reagents minus the mass of the total post-reaction system


1. Diseñen en el recuadro un equipo recolector de gases para la reacción demostrativa del docente y luego experimenten su funcionamiento.

Disconfirmation

The Lomonosov-Lavoisier Law indicates that the total mass of substances present after a chemical reaction is the same as the total mass of substances before the reaction.
"So, our hypothesis was wrong"

Evaluation

The students weighed the reagents and materials before the reaction, and they did it as it was showed. Then, they weighed the closed system when the reaction stoped. By mass difference, they found a value of zero.

What does the Law of Conservation of Matter establish?

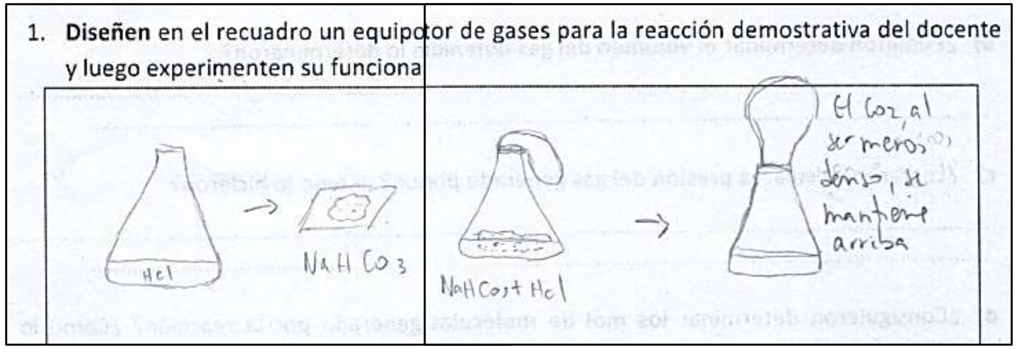
Results

Results

2nd GEM cycle: Mass difference between balloon and gas+balloon

Generation

The students will collect the $CO_2(g)$ in the balloon, to weigh only the gas captured inside the balloon. "The CO_2, being less dense, will stay up"



Disconfirmation

"It occupies the entire container that contains it, so if the flask and the balloon were connected without separation, it is possible that $CO_2(g)$ has also remained inside the flask"

Evaluation

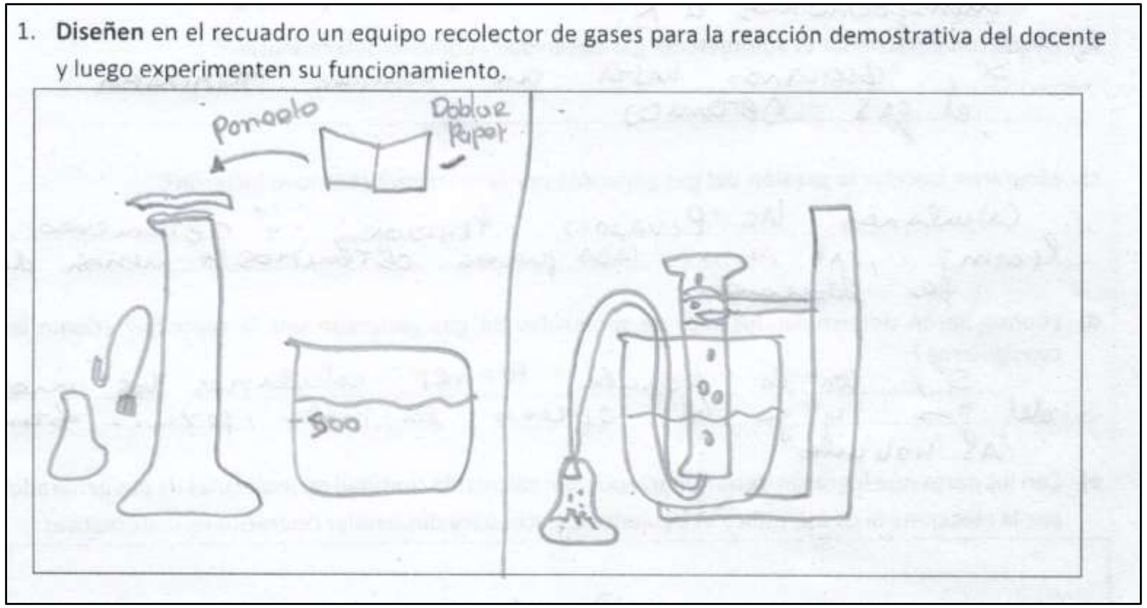
The students:
1) performed the reaction,
2) captured the $CO_2(g)$ inside the balloon,
3) weighed the balloon + $CO_2(g)$, and
4) determined the mass of $CO_2(g)$ by substraction, having the mass of the balloon.

Are you sure that all the $CO_2(g)$ is inside the balloon? What do you remember about the properties of a gas inside a container?

Results

Results

5^{th} GEM cycle: Using a wet gas collecting device


1. **Diseñen** en el recuadro un equipo recolector de gases para la reacción demostrativa del docente y luego experimenten su funcionamiento.

Generation

Conversation with students about what they found out to collect a gas: Wet Gas Collection Device

Evaluation

The students collected the $CO_2(g)$ in the graduated cylinder and determined the volume occupied by the gas using around 1.0 g of $NaHCO_3(s)$

Modification

"It seems that we have to work with less amount of $NaHCO_3(s)$"

The $CO_2(g)$ generated escaped from the inverted graduated cylinder

Results

Results

Conclusions

- The students were able to adapt easily to the challenge. In fact, they recognised they were prompted to work in the challenge joyfully since it was a new experience.

- The students' model generation confirmed five successive teacher-student GEM cycles to achieve the objective.

- The study itself needs a second cycle of depuration. For example, we should include a larger sample of students.

Conclusions

Thank you very much for your attention