INQUIRY BASED LEARNING FOR ADDRESSING MISCONCEPTIONS ON THE GREENHOUSE EFFECT

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Summary

- Misconceptions. Misconceptions on greenhouse effect
- How to address misconception at school
- Methodology for hitting misconceptions
- Model of Inquiry Based Learning
- IBL didactic unit on gases
- Evaluation of students' attitude during the didactic unit implementation
- Conclusion

The misconceptions

Misconceptions are ideas that are not in agreement with the correct understanding of a phenomenon.
https://www.youtube.com/watch?v=oBdalzRJR5g

Regarding the greenhouse effect, students and general public frequently show an unclear idea of how it works. It is very common to hear that …

"The greenhouse effect is due to ozone depletion"

"Human activities alone are what cause the greenhouse effect"

"The greenhouse effect is caused by certain molecules that trap and amplify the outgoing infrared energy"

How to face the misconception at school

MisstoHit project (2015-2017 - From misconceptions to learning insights through inquiry with playful physical objects - funded by the Erasmus+ Programme, **aimed to address the misconceptions that many students have in relation to a variety of STEM topics.**

10 didactic units were elaborated by scientists and teachers and educators in science museums to address selected misconceptions.

These were identified by a group of 100 teachers as the most common among the students and significant.

http://misstohit.deusto.es/

Students do not come to school as a 'tabula rasa'. They bring ideas or conceptions about scientific phenomena into the science class that are not always in agreement with our current understanding of natural science. These alternative conceptions are often referred to as 'misconceptions'. Usually such misconceptions are robust, very resistant to change, deeply rooted in everyday experience, and rather useful in explaining everyday life phenomena.

Misconceptions are ideas that are not in agreement with our understanding of natural science. A familiar example of misconception that teachers hear from students is the idea that gases are not matter because they are invisible and they have not mass.

Misconceptions are ideas that are not in agreement with our understanding of natural science.

Addressing misconceptions

Students' misconceptions can be tackled with observations and active exploration in experiments that use physical objects and hands-on activities.

During the first phase of the project, teachers of secondary schools have identified 30 misconceptions in a variety of science subjects. These misconceptions are addressed through the creation of effective learning activities that use low cost physical objects. The activities follow a structured approach of Inquiry-based Learning and take into account the gender equality during the application in the classroom or in other contexts.

Methodology for hitting misconceptions:

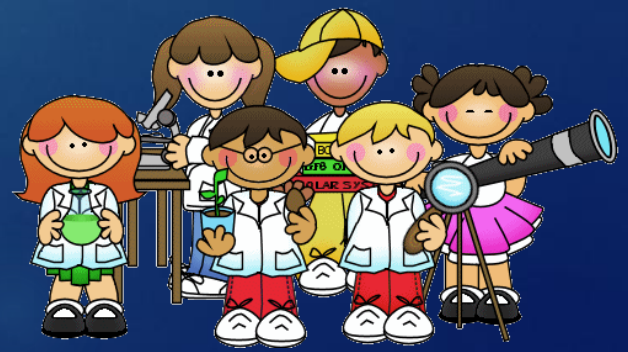
- The didactic units were developed following **Inquiry-based Learning (IBL)**
- IBL is an approach to teaching and learning that places students' questions, ideas and observations at the centre of the learning experience.

  IBL includes active participation

  IBL is self- directed

  IBL generates new knowledge to the learner
- Educators play an active role throughout the learning process: all ideas and hypothesis are respected, tested, redefined and viewed as improvable. Students move from a position of wondering to a position of understanding and further questioning (Scardamalia, 2002).

Both educators and students share responsibility for learning.



Models of Inquiry Based Learning

There are many models of IBL available, even dating back to the '30ies!.

In 2015, Pedaste et al. made a review of all the existing models and found that different descriptions of inquiry models in the research literature, use various **terminologies to label phases that are essentially the same**.

Dewey (1933) outlined several important aspects of inquiry-based learning, such as defining a problem, formulating a hypothesis, and conducting tests. Later on, interaction between phases, sequencing of phases, modifications in terminology, more definitions were introduced. However, contemporary inquiry cycles implicitly reflect aspects of earlier frameworks.

White and Frederiksen (1998) proposed an inquiry cycle of five inquiry phases: Question, Predict, Experiment, Model, and Apply.

The 5E learning cycle model (Bybee 2006) is made of five inquiry phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

Summarized model of IBL used for hitting misconceptions

Pedaste et al. resumed the Inquiry Based Learning phases from different frameworks into 5 phases:

Orientation	*The process of stimulating curiosity about a topic and addressing a learning challenge through a problem statement.*
Conceptualization	*The process of stating theory-based questions and/or hypotheses based on the stated problem.*
Investigation	*The process of planning exploration or experimentation, collecting and analysing data.*
Conclusion	*The process of drawing conclusions from the data. Comparing interpretations made based on data, with hypotheses or research questions.*
Discussion	*The process of presenting findings of particular phases or the whole inquiry cycle by communicating with others and/or controlling the whole learning process or its phases by engaging in reflective activities.*

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Greenhouse effect - Miss to Hit

misstohit.deusto.es/activity-3/ 80%

GREENHOUSE EFFECT

We developed an IBL didactic unit to address the misconceptions on the greenhouse effect, by focusing the students' attention on different gases and their temperature under a heat source.

The activity was tested by 70 students of 2 high schools.

Erasmus+

DIDACTIC UNIT

GENERAL INFORMATION

Title: Greenhouse effect: harm or benefit?

Misconception:

- The greenhouse effect is bad for the Earth

Domain (area, subject, topic, concepts): Chemistry: air chemical composition; Physics: temperature and measure unit, relationship between gas and temperature

Learning objectives:

- Understanding of the gas properties in connection to solar radiation;
- Understanding what a greenhouse gas is;
- Understanding the difference between natural and anthropogenic greenhouse effect;
- Designing an experiment but also measuring and calculating;
- Enhancing group work;
- Manual skills in relation to setting up an experiment.

Keywords: greenhouse gases, non-greenhouse gases, heat trapping capacity, temperature

Number of activities:

Resources and material needed:

The students will work in 5 groups of 3-5, testing different gases or gas mixtures and their results will be finally compared.

Despite the Earth and the Moon are at about the same distance from the Sun (150 million kilometers) they have completely different temperatures, obviously linked to their genesis and evolution, and presence of the atmosphere. The atmosphere is the sphere of gases around the Earth and some of these gases cause the Greenhouse Effect.

Do you think the greenhouse effect is bad for Earth?

Answer the following questions (Time: 10 minutes)

Which are greenhouse gas among these?

- ☐ Carbon dioxide
- ☐ Methane
- ☐ Nitrous oxide
- ☐ Helium
- ☐ Water vapour
- ☐ Nitrogen

What is the origin of the greenhouse gases?

- ☐ They are produced inside the greenhouses

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Didactic unit on the greenhouse effect

Learning objectives:

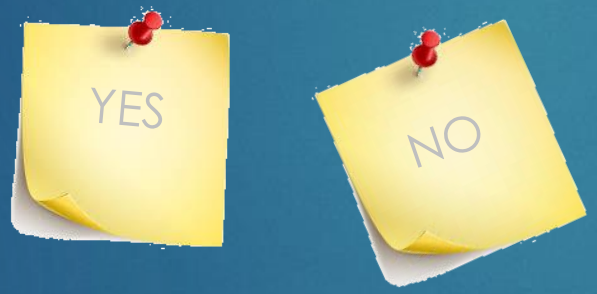
- Understanding of the gas properties under solar radiation;
- Understanding what a greenhouse gas is;
- Understanding the difference between natural and anthropogenic greenhouse effect;
- Designing an experiment but also measuring and calculating;
- Enhancing group work and manual skills

Misconception:
"The greenhouse effect is bad for the Earth" (in absolute)

Age and educational level: 12-16 years old; 1°-3° grade of the secondary school
Previous knowledge required: base knowledge of gas and atmospheric gas composition; greenhouse effect.

Orientation

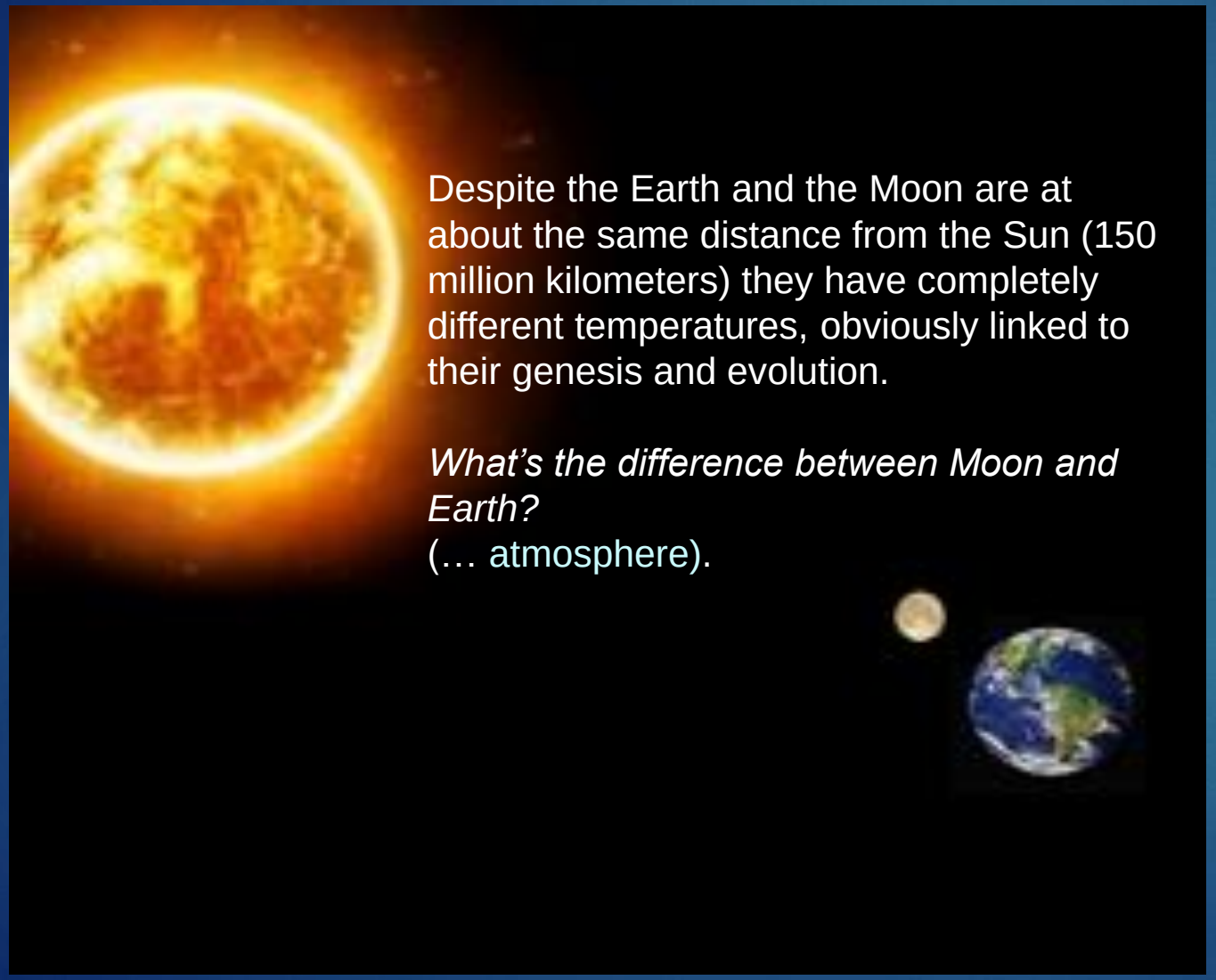
Do you think the greenhouse effect is bad for Earth?



What would the Earth be without it?

Students are introduced to the topic

Orientation



Students recall prior knowledge

Orientation

What is the atmosphere composition?

…

Which among these are greenhouse gases?

- ☐ Carbon dioxide
- ☐ Methane
- ☐ Nitrous oxide
- ☐ Helium
- ☐ Water vapour
- ☐ Nitrogen

What is the origin of the greenhouse gases?

- ☐ They are produced inside the greenhouses
- ☐ They are in the atmosphere, naturally present
- ☐ They are produced only by man

Students recall prior knowledge

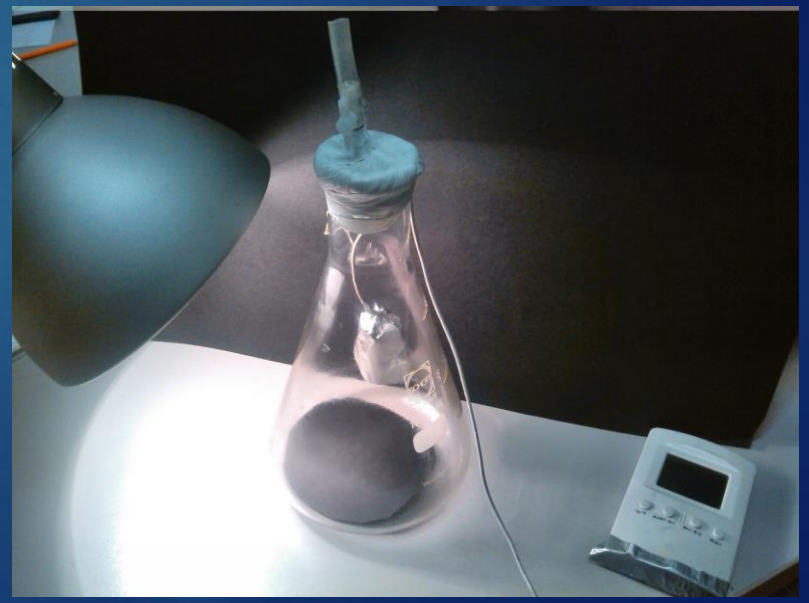
Conceptualization

Which is the relation between gases and temperature?

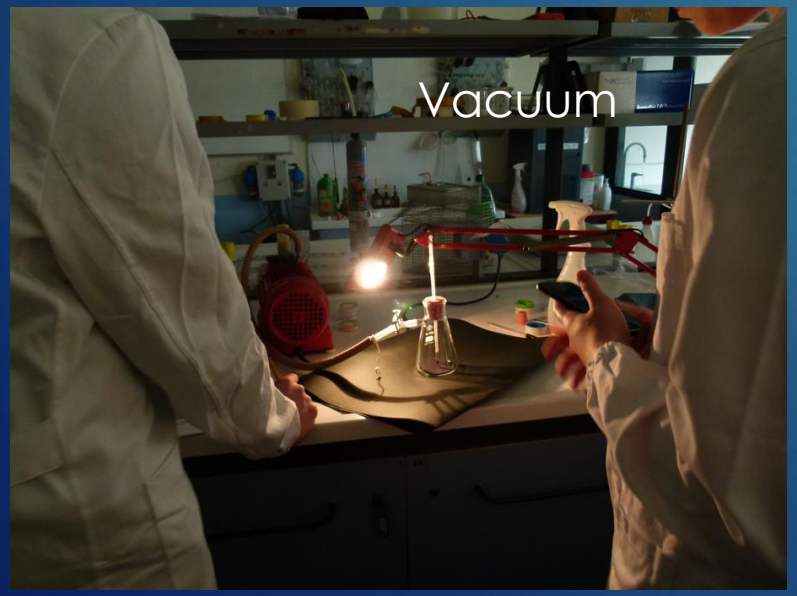
If you fill in a bottle with a gas and put it under a radiation source (e.g. Sun), how will the gas temperature change (increase/decrease/no change)?

Students make their own hypothesis

- They think freely, within the limits of the activity
- They formulate predictions and hypotheses
- They ask related questions



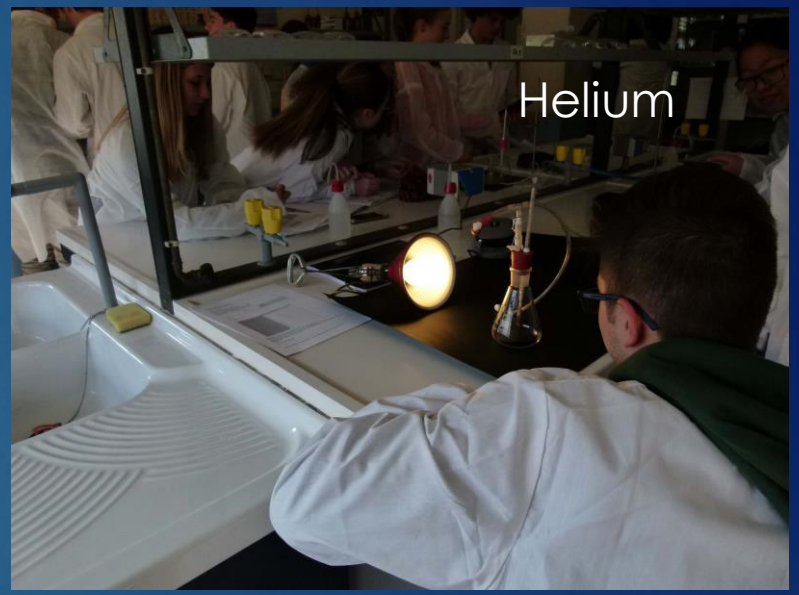
Investigation



Students design an experiment to test their hypothesis.

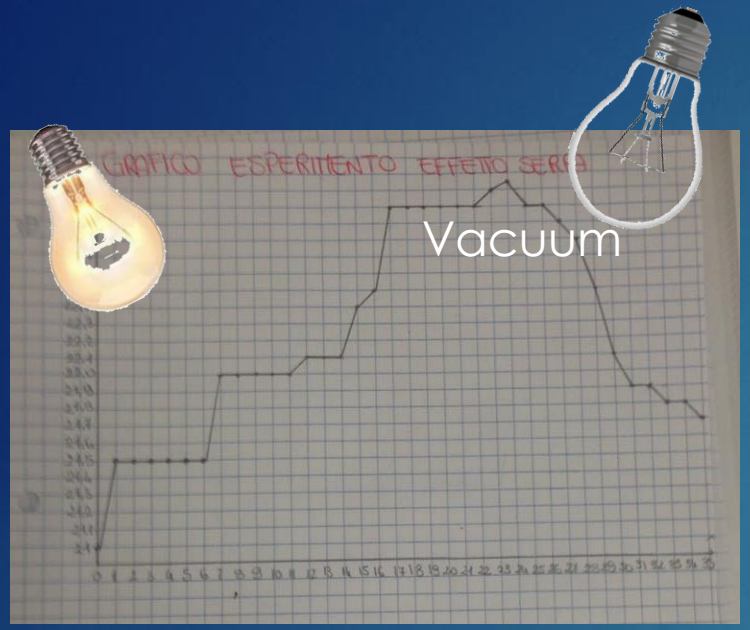
The investigation is successful if partially guided by the teacher. Students ask questions, find problems, ask their peers or their teacher an explanation.

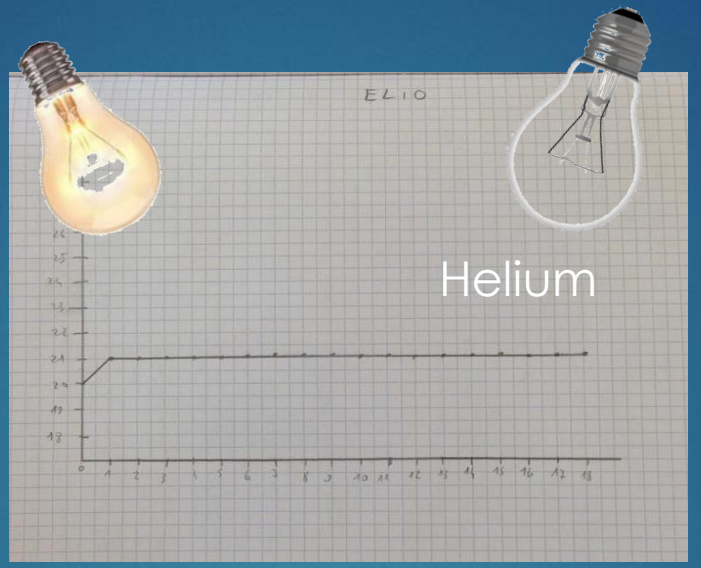
Judgment is suspended
Critical thinking arises

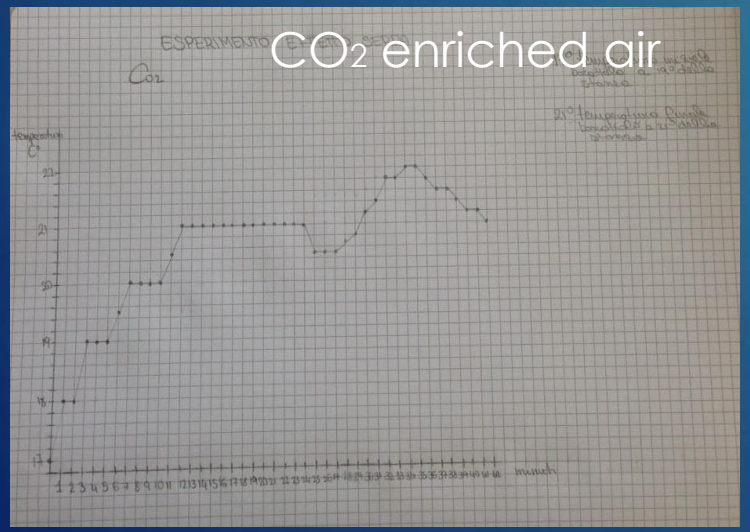


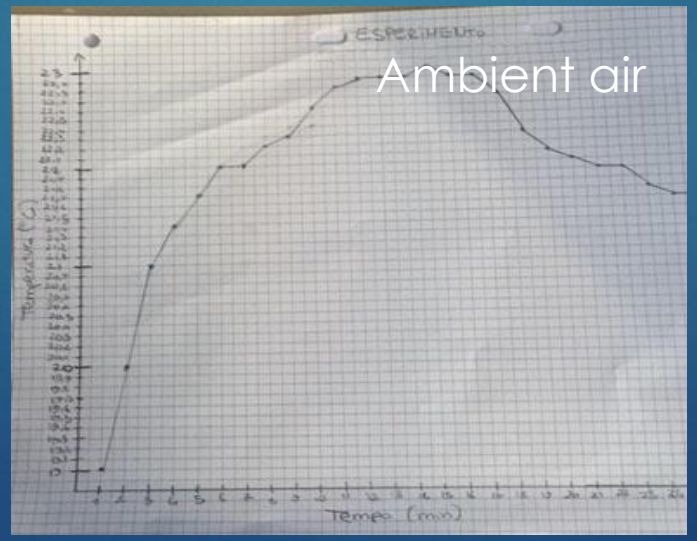
Students compared different gas situations, by playing also with external variables.

Investigation









Students record and elaborate the data.

Students recorded the temperatures of gas mixtures under the heat source and without it. Attention focused on the cooling phase.

Cooling phase of mixtures with greenhouse gases (ambient air and air enriched with CO2) takes longer.

Conclusion

Which gas or condition does get the highest temperature?
Which gas or condition does get warm faster? (raise of temperature per time unit)?
Which gas or condition does cool down more slowly and which is faster (decrease of temperature per time unit)?

The teacher
- Formally clarifies definitions, explanations, and new labels when needed
- Uses students' previous experiences as the basis for explaining concepts
- Assesses students' growing understanding

The students
- Use recorded observations and explanations to draw reasonable conclusions
- Listen to and tries to comprehend explanations that the teacher offers
- Refer to previous activities
- Assess own understanding

Students compare their results; They gather all groups' data and make their own conclusions, explaining the difficulties met and the solutions.

Discussion

Then, the discussion focuses on the results of the experiment extended to the original question.

- *What's the relationship between Earth's temperature and gas?*
- *Some gases have the capacity to trap heat, what's the role of the greenhouse gases for Earth's atmosphere?*
- *Some gases have the capacity to trap heat, what may it happen when the Earth's atmosphere has too much GHG?*
- *So, is the greenhouse effect always bad?*

The students
- Present the results
- Demonstrate an understanding or knowledge of the concept or skill
- Evaluate his or her own progress and knowledge
- Ask related questions that would encourage future investigations

The teacher
- Looks for evidence that the students have changed their thinking or behaviors
- Allows students to assess their own learning and group-process skills
- Assesses students' knowledge and skills

Evaluation of students' attitude

Attitude in piloting a scientific methodology was assessed by submitting a "flow and worry" questionnaire to 70 students.

Questions	Average	St. Dev.	Strongly Agree & Agree
1. I felt just the right amount of challenge during the activity. (F)	3.6	0.96	69%
2. The activities I had to perform run fluidly and smoothly. (F)	3.7	0.88	70%
3. I did not notice time passing. (F)	3.9	0.90	74%
4. I had no difficulty concentrating. (F)	3.9	0.89	80%
5. My mind was completely clear during the task. (F)	3.8	0.80	74%
6. I was totally absorbed in what I was doing. (F)	3.7	0.85	69%
7. I knew what I had to do each step of the way. (F)	3.7	0.84	66%
8. I felt that I have everything under control. (F)	3.6	0.90	56%
9. I was completely lost in thought. (F)	1.8	1.04	9%
10. I was sure that I would not make any mistake during the task. (W)	3.2	1.01	34%
11. I was worried about failing during the activities I had to perform. (W)	2.6	1.14	21%

Table 1. Responses of students to the questionnaire about "flows (F) and worries (W) " performing the activities. The questionnaire responses were according a 5-point Likert scale: Strongly Agree (5), Agree (4), Nor agree nor disagree (3), Disagree (2), Strongly Disagree (1).

Conclusion

- The experience of Inquiry-Based Learning raises curiosity and allows experimentation to take over.
- Students face problems to which they have to find solutions, improving critical thinking, problem solving capacity and decision-making skills
- Team work is successful
- Students have a positive attitude toward the activity's organization, however, the methodology requires time
- The experiments must be tested prior the activity is carried out with the class because it might happen that misconceptions are reinforced if the experiment doesn't work.

Thank you for your kind attention

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