Venice Office
Regional Bureau for Science and Culture in Europe

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"BOILING AND PEELING OF EGGS"

Sample Lesson Plan for Teachers under the Ark of Inquiry Project

Ark of Inquiry: Inquiry Awards for Youth over Europe" is a project on teacher training, oriented towards raising science awareness, particularly that of youth aged 7 to 18, to Responsible Research and Innovation, (RRI). It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTIVITY 5.2.2 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education. This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612252.

Summary

The following lesson plan was designed by the University of Cyprus group in accordance to the inquiry-based framework provided by Professor Margus Pedaste et al. (2015)[1]. The lesson plan focuses on the experimental side of boiling and peeling eggs, an experiment that allows students to develop certain skills as they go through each phase of inquiry-based science learning.

Aim and Objectives

The main aim of this lesson plan is to prompt learners into engaging in multiple inquiry cycles through the curriculum and become acquainted with how inquiry-based learning works.

This is accomplished through communication and discussion between the teacher and students; actual hands-on experience provided by conducting a scientific experiment; action-based results that are to be reached by the students themselves; and, collection of data which is to be presented in the classroom for further discussion and peer feedback.

By the end of the lesson, students will have experienced inquiry-based learning, engaging in a hands-on experiment, as well as communicating, and giving and receiving feedback. Additionally, according to Pedaste et al. (2015), the following experiment is to be conducted in groups and more specifically groups of four (4), prompting the equal participation of all the students in the class and the development of team work.

Time and Materials needed for the lesson

As for any experiment taking place in real life, there are specific materials and a certain time frame that needs to be followed. Keeping this in mind, the following activity of "Boiling and Peeling Eggs" **will last approximately 125 minutes which comprise about 3 didactic hours (45 minutes each)**.

The materials used for the whole activity are summarized in the following list:

- Computers with an internet connection and/or printed copies of articles and scientific publications
- Video material
- Projector
- Eggs (the number depends on the number of the students, but the teacher should bring more eggs as a surplus for each group of students)
- Since the experiment will be performed in the school, a fully functional and equipped kitchen is necessary
- Notebooks, pens, papers, pencils, markers

[1] *Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A., Kamp, E. T., Manoli, C. C., Zacharia, Z., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational research review, 14, 47-61.*

Orientation phase

The learners are provided with a scenario that relates to a chef's daily task about boiling and peeling eggs for the customers of his restaurant. Because of the difficulties he encounters during performing this task (e.g., quite often the eggs are not hard boiled enough and thus they are neither easily peeled nor are uniformly peeled), learners are prompted to find solutions to the chef's problem by answering the following driving question:

"How can one make perfect hard boiled eggs that are easy to peel?"

The students are then ready to:

1. Define the problem that merits solution,
2. Identify the variables that might affect the boiling and peeling of eggs,
3. Perform some reading and study from internet resources to get familiar with the context of the problem, and
4. Collect information about the processes that take place during the boiling of eggs (e.g., protein denaturation).

***Time needed for the orientation phase**:* 15 minutes
***Materials**:* Videos, projector, printed copies of internet resources and/or other scientific publications, and/or computers with an internet connection

Conceptualization phase

In this phase, teachers ask learners to formulate **investigative questions**. First, they are prompted to fill in the blanks in given investigative questions, where the independent and dependent variables are omitted.

An example would be **"Does the…… affect the …….?"**

After learners have correctly completed the blanks with the variables needed, they are asked to identify themselves the syntax of an investigative question. At this point they are informed that any investigative question follows the same format and it always entails two variables—the one that will be varied (**independent variable**) and the one that will be measured (**dependent variable**) during the experiment—that are connected through the verb **"affect"**.

Investigative question= Dependent variable + Independent variable combined with "affect"

Next, the learners are supported in developing hypotheses that derive from their investigative questions. In doing so, they are prompted to provide a **possible explanation of the relationship between the two variables** that each of the previously investigative questions entails.

Right after, the teacher explains what a hypothesis is and the way to formulate one:

Hypothesis Definition: A hypothesis is a plausible explanation for an observed phenomenon that can predict what will happen in a given situation.
How to formulate a hypothesis: "If variable A *increases/decreases*, then variable B will *increase/decrease/remain constant*" or "The *more/less* the variable A is, *the more/less* the variable B will be.''

In order to apply what they have learned about hypothesis generation, the learners are encouraged to formulate hypotheses based on the identified variables that might affect the boiling and peeling of eggs.

Follow-up activity: teachers provide learners with 9 statements (**3 hypotheses**, **3 predictions**, and **3 guesses** in the context of boiling and peeling eggs), and they are asked to discuss with their peers and identify those that entail an explanation of **how** and **why** a phenomenon functions (i.e., hypotheses), those that point to the outcome of an experiment (i.e. predictions) and those that are mere guesses.

Time needed for the conceptualization phase: 20-25 minutes
Materials: Nothing in particular

Investigation phase

This phase was developed according to three inquiry levels: **Level A (basic inquiry), Level B (advanced inquiry) and Level C (expert inquiry)**. In every level, pupils design and perform a controlled experiment to answer their question and test their hypothesis. Teachers decide the level of their students and proceed accordingly.

Level A

In the first experiment, the investigative question "**Does the egg's age affect the boiling and peeling of eggs?** ''is given in order for all groups of pupils to conduct the same experiment. Initially, learners are prompted to suggest a **controlled experiment** for answering the given investigative question without receiving any scaffolds on how to perform this task or feedback on their experimental design proposal, since the purpose of this activity is to **enable the elucidation of learners' prior conceptions and level of skill acquisition about the design of controlled experiments.**

Next, the learners are engaged in a structured activity sequence where they have to identify three things:

a) the variable that needs to be **varied** in their experiment (i.e., the age of the eggs),
b) the variables that need to be kept **constant**, and,
c) the variable that has to be **measured** (i.e., the boiling and peeling of eggs).

For each of the identified variables, the learners are prompted to specify how this would be treated for the purposes of their experimental design. For instance, for the peeling variable, the learners are expected to describe a procedure through which the peeling percentage can be measured. As soon as each group of pupils finalizes their experimental design and receives feedback from the instructors, they make

a) a **prediction** (e.g., what is the anticipated outcome of the experiment) and,
b) a **hypothesis** (e.g., provide an explanation to justify their prediction)

based on the investigate question, and then they **proceed in performing their experiment** which follows the steps below:

1) Students are expected to choose **two eggs of different age** (e.g., a 3 day egg and a 15 day egg),
2) Keep all other variables constant for both eggs (e.g., eggs' mass and volume, both eggs should originate from the same hen, the volume of the water that each egg would boil in should be the same, etc.),
3) Record data about the peeling percentage of each egg and after boiling and peeling both the eggs they were given.
4) At this stage, the learners plot their data using the most appropriate means for their representation (e.g., a line graph, a bar chart, etc.) and they are prompted to interpret their data in relation to their investigative question, and verify whether their predictions and hypotheses are **confirmed or rejected**.

Extension Activities

Before proceeding to the Conclusion phase, the learners are engaged in two activities that **serve as extensions to the development of their experimental design skill**.

1) The first activity pertains to a given experimental design in the context of "peeling and boiling eggs'' that does not meet the requirements of a controlled experiment (e.g., there are more than one variables that are altered during the experiment), and learners are asked to comment on whether the given experimental design refers to a controlled experiment and suggest improvements in order to correct its flaws. The same activity is repeated with a new experimental design in a new context and learners again are asked to identify the experimental flaws and suggest improvements.

2) The second extension activity concerns learners' initial experimental design that was suggested in the beginning of the Investigation phase. In order to help learners **evaluate the development of their understanding about the design of valid experiments**, they are asked to revisit their initial experimental design in order to assess whether their experimental design was valid or not. In the case they find that their experiment was not valid, they are prompted to suggest improvements. As a follow up activity, they are asked to define the steps that should be followed in designing and conducting valid experiments.

Tip for peer communication and feedback: To help **peer interaction and communication** in order to check whether each group of learners reached the same interpretations based on the data collected, they are asked (as a group) to upload their collected data in a google form that is open for public view. This will enable learners to compare their data with the data derived from their peers' experimental designs and use them for secondary analysis and new interpretations.

Time needed for Level A of the Investigation Phase: 40-45 minutes
Materials: the experiment should take place in a kitchen where students will be able to boil their eggs. The number of eggs depends on the students, but as a contingency plan the teacher should bring a surplus of eggs (2 more for each student). A number of pots should be available for the students to use to boil their eggs in. Students should have access to a computer room where they could record their data into tables and graphs and share their feedback with their peers through Google docs.

Levels B and C

The structure of activity sequence described for Level A is repeated for Level B (advanced inquiry) and Level C (expert inquiry) during which learners choose new investigative questions and subsequently design and conduct new experiments.

The difference between each level lies on the type of supports and scaffolds that learners receive throughout the curriculum.

Specifically, during Level B, learners are asked to formulate the investigative question they are about to test themselves, and then they are provided with a table on which they have to define the variable that should be tested, the variables that should be kept constant, and the variable that should be measured. For each of the variables they are asked to define and specify the ways they will manipulate them during performing their investigation. They are also asked to formulate a hypothesis and subsequently a prediction, based on their investigative question. For each of these tasks, the learners are provided with some hints that point to specific activities that were implemented at a prior stage at the curriculum during Level A in case they need help on how to perform a specific task or refresh what they have already learned during Level A.

During working with Level C activities, learners are asked to formulate a new investigative question and they are allowed to decide what to do for answering it. They are provided with enough space to organize their work in a similar manner they were instructed to do during Level A and Level B activities.

Conclusion phase

Learners draw **conclusions** based on the data collected during the preceding phase. Specifically, they create **a two-column table to distinguish the variables** that were found to affect the boiling and peeling of eggs from those that do not affect it. This table will be updated based on conclusions that will be made during the subsequent inquiry-based cycles through which the learners will seek to respond to other investigative questions pertaining new variables that might affect the boiling and peeling of eggs.

Time needed for the Conclusion phase: 15 minutes
Materials: Nothing in particular

Discussion phase

Learners prepare a **poster in order to communicate their findings** with their peers. In doing this, they need to think of ways to illustrate how they worked as a group during each phase of the inquiry-based cycle and decide the data and the way these should be represented on their poster. Once they finished their poster, they are asked to organize a **5-minute presentation for their peers** as a means to communicate the procedure they applied. Additionally, they are prompted to reflect on:

a) the process of inquiry followed during working with the curriculum materials,
b) the practical difficulties and problems they encountered during each of the inquiry phases, and
c) the possible changes that would follow if they were about to further investigate the boiling and peeling of eggs.

Time needed for the Discussion phase: 10 - 15 minutes
Materials: Depending on how the students will choose to create their poster, they will either need computers and a projector for their 5-minute peer presentation or they would need markers and notebooks to draw the poster themselves.