BYOD to enhance students motivation in STEM learning

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Abstract

During more than 20 years of my professional carrier as teacher and pedagogical advisor, it has become clear to me that classes should be made more colourful, attractive and interactive, independently of the teaching level (higher education or lower educational level [1]), and of the type of the subjects. Analysing students' attitude to work in details, I also concluded that students' motivation in STEM learning and teaching should be enhanced. Students need more fun, more attractive and interactive activities, where they can be involved and take part with pleasure. Members of this generation should be prepared to be active learners; they should follow the general path and steps of inquiry and research: make observations, form hypotheses, do a test or experiment and make reflections and conclusions. In order to improve our students' key competencies we should let them bring their devices [1] (BYOD), and use them for educational activities (assessments, hands-on experiments, measurements, simulation, etc.). During the pandemic period another method had to be introduced: teleconferencing, performed with MS TEAMS or ZOOM (delivering lectures and talking about simulated events, explaining a physical phenomenon). The aim of this work is to share some good examples, resources and methods to enhance students' motivation, or present different types of educational methods like cooperation, project method, IBL or flip classroom [2]. Each example has already been used by me, or will be used shortly in high school and college BSc level. Some activities include gamification ("Escape room") and group-work activities, contain students' and teachers' guides and self-evaluation tools, like multiple choice questions, interactive exercises with simulation, theoretical exercises etc. All examples are related to study of the basic laws of Physics with more fun and enthusiasm. Students should leave high schools, universities and colleges with an adequate knowledge and with applicable skills in STEM, therefore we should help them to achieve this.

Keywords: hands-on experiments, BYOD, ICT, multimedia, interactive activities

1. Introduction

In the beginning of lockdown period of COVID-19 many new questions raised up, which had to be solved immediately. It was a real challenge for both students and educators.
In this paper some selected, adaptable examples, with different methods applied will be presented, which were used in Physics teaching to increase the students' motivation and to develop their learning and innovation skills, digital literacy skills, and career and life skills [3].

2. Target, participants

The following implementations have been done in the past and will be done again with my students from high school and college BSc level who are enrolled to compulsory Physics classes.

3. Teaching methods used

The main teaching theories can be divided into two categories: teacher-centred and student-centred learning. Every teacher can decide which method is more appropriate in his/her educational environment, and especially in online courses. During this period I used different types of methods.

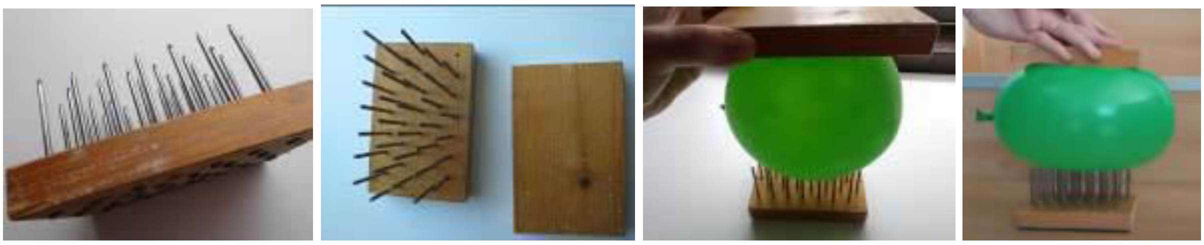
3.1 Cooperation method

Participants involved in the cooperation method are expected to be engaged in group work, where the classroom is transformed into an attractive environment. Students enrolled to the activity usually have very different background knowledge [4]. Unfortunately during the lockdown period of COVID-19 the method had to be transformed online. In this sense this activity was kind of a pilot project that tested the solutions involving aspects of motivation, collaboration, creativity and confidence as well as self-paced and personalised learning. I used this method to make students to understand better the physical properties of the **pressure**, and its types and laws.
Some students were involved in performing the hands-on experiments, some have prepared some fun quiz questions, and some others were working out some problem solving exercises.

Before starting the experimental activity the students had to make some predictions, collect the requested materials and set-up the experiment.

1st experiment

This experiment (Fig.1), required a balloon, two pieces of wood plates and approximately 30 iron nails with the same size.



1. Figure: exploring the meaning of pressure

Students had to press down the balloon, applying a force on the wood plate at the top and observe, what was going on. After the experiment students started their online conversation for developing and improving their critical-thinking and argumentum skills.

Students finally concluded, that the balloon was not burst because the applied force was equally distributed on many nails, they also have learned the definition of the pressure.

$$p = \frac{F}{A} \qquad [p]_{SI} = 1Pa = 1\frac{N}{m^2}$$

2nd experiment

Another group studied the dependence of the pressure of a gas on the temperature. This experiment required an egg and Erlenmeyer flask or milk bottle preheated by some boiling water. After that a peeled hardboiled egg was quickly placed on the top of the Erlenmeyer flask (Fig. 2).

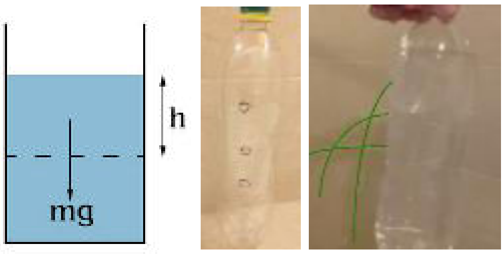
2. Figure: Egg in the Bottle, in the Erlenmeyer flask or milk bottle

After a short time the egg was “sucked inside” the flask (the students’ words). In the discussion of the experiment the conclusion was that the preheated air inside the flask cooled down, and therefore its pressure decreased, and the larger pressure of the outside air pushed the egg inside the flask. (Additionally, when the flask cools down, some remnants of the water vapour from the boiling water condenses, which also contributes to the decrease of the pressure inside the flask).

In addition to discussing the general concept of pressure and the effects of pressure change, this experiment can also be applied when one is teaching Gay-Lussac laws.

3rd experiment

A group of students studied the hydrostatic pressure with the third experiment at home using only a PET bottle. They had to predict, and observe what happens, when they made holes at three different heights.



3. Figure: exploring the dependence of the hydrostatic pressure

With a simple tape they even could measure the largest distance.
After analysing and discussing students concluded that the hydrostatic pressure depends on the height.

$$p = \frac{F}{A} = \frac{m \cdot g}{A} = \frac{V \cdot \rho \cdot g}{A} = \frac{A \cdot h \cdot \rho \cdot g}{A} = \rho \cdot g \cdot h$$

When the atmospheric pressure acts on the surface of the liquid, it should also be taken into account.

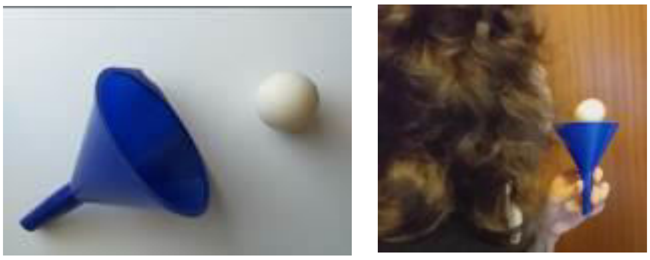
$$p = p_0 + \rho \cdot g \cdot h$$

4th experiment

Aim of this experiment was to understand Bernoulli's equation. The students needed to have a hair dryer and a ping pong ball.
Observing the movement of the ping pong ball students concluded that the ball usually was trying to escape from the vertical airflow but was directed back into the airflow by the higher pressure of the surrounding dormant air.

4. Figure: exploring Bernoulli's principle with hair dryer

A funny experiment was also done at home, which requires only a ping pong ball, and a funnel from the kitchen. The aim is to blow out the ball from the vertically held funnel. At first one usually tries to blow out the ball from the bottom of the funnel, but one should realize that it is not possible. However, when blown sideways over the funnel (Fig. 5.), the ball gets “lifted” and easily removed.



5. Figure: Ping Pong Funnel Experiment

As a result of the experiments presented, students concluded that the pressure in liquids (and gases) depends on the flow rate as well as the hydrostatic pressure. They better understand now the Bernoulli law:

$$p+\frac{1}{2}\rho\cdot v^2+\rho\cdot g\cdot h=const$$

During these exciting and successful activities students learned to make observations, formed hypotheses, made their fun experiments, discussed the topic and deduced their conclusions. They were involved in teaching and learning procedure through the camera, using their own devices, and own tools for experiments.

3.2 Project method

In the project method students solve a practical problem over a period of several days or weeks. This method has many advantages because it can be used even online, and participating students can carry out activities according to their interests. I have been using the project method with my students already for a long time. All measurements have already been published in details in a conference proceeding [5]. The novelty in this semester lies in the fact that we will do everything online.
The goal of each of the suggested experimental methods is to determine the value of the gravitational acceleration. Students can choose one of these:

- recording and analysing the sound of a ball rolling and free falling
- video recording and analysing the movement of a free falling ball
- use the Phyphox free apps designed by Aachen University

For all methods, students have to determine the value of the gravity acceleration (g) and estimate the uncertainty of their measurement.
I hope that all students will find a task that suits their interests, but will also learn mastering their own tools, learn about error calculation, and be able to compare the measured results with the value published in the literature.

3.3 Inquiry-based learning

IBL is based on the constructivist conception of learning, which involves the followings: developing questions, making observations, find out what information is already known, outlining possible explanations and creating predictions for future study.
All this expectations are embedded in the activity performed with the students. During one of my Physics course my students offered voluntary their participation in this method.
IBL was used for understanding the “Plum pudding model of atom” proposed by J. J. Thomson in 1904.
A simple experimental tool was constructed by the students, so that the “Thomson’s atomic model” could be more easily understood.
Thomson supposed that the atom is made of a positively charged bulk (like a pudding), and it contains electrons scattered (like some raisins inside the pudding).
Although the electrons repel each-other, the positively charged bulk holds the whole thing together.

The students constructed a model from the following components:
30 cm diameter glass bowl,
10 cork plugs with a diameter of 4 cm,
10 pieces of 3 * 30 mm strong neodymium magnet,
30 m Teflon coated coil of copper wire,
9 V battery,
glue gum

6. Figure: Use of Inquiry-based learning to study the plum pudding model proposed by J. J. Thomson

The magnetized needles represent the electron-"raisins", because they repel each other. The particles swim as far apart as possible. The attractive force of the "pudding" is provided by the magnetic field of the coil. It should be noted that here we use magnetic forces, whereas in the Thomson model electrostatic forces are in play! Discussing the experiment students observed that the particles always were arranged in the most symmetric way, even after their movement towards the centre of the vessel. The students informed me about their feelings and their worries. They felt that constructing this experimental equipment was a huge experience in their life. They will never forget this material.

4. Conclusion

Students in my Physics courses gave me very positive feedbacks. Based on the results and on personal interviews I conclude that they became better motivated because they were required to do an experiment, to start discussing, observing and predicting about a phenomena. I hope that their enthusiasm will not disappear after returning to normal education system, and they will still be motivated enough to make similar experiments also in the classroom. I am confident that these attractive and understandable lectures can better attract our students to the course and their motivation for measurements can be enhanced by using their own devices.

5. References

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