Liquid Lenses Created in Space – Lesson/Activity Plan for Junior High School Teacher

Content: Physics, multidisciplinary

Age range: Junior high school

Activity duration: 90 minutes (double lesson)

Location of lesson: Classroom or laboratory

Rationale

This activity pertains to the Liquid Lenses experiment. The experiment is being sent to the International Space Station with Israeli astronaut Eytan Stibbe as part of the Rakia Mission. The lesson focuses on how liquids on Earth behave differently compared to liquids in space; and on what needs to be considered when converting an experiment that takes place in a lab under the Earth's gravity, to an experiment that an astronaut will conduct on the space station in microgravity conditions.

Activity Objectives

1. To learn about the liquid lens experiment in space.
2. To learn about how microgravity may impact the experiment.
3. To foster a culture of thinking together and discussion in class.

Description of the activity

In the first part of the activity, the pupils will get to know Prof. Moran Bercovici (by watching the video). Prof. Bercovici will explain the experiment conducted in his lab on Earth. The scientist will explain why he wanted to attempt the experiment in space (for the sake of future developments in space and on Earth), and will ask the pupils to help him plan the experiment in space.

After watching the video together, the teacher will divide the class into groups (up to five pupils per group), where they will discuss the following: how substances in general, and liquids in particular, behave in microgravity; the elements that must be added or removed from the original experiment; supplies that must be taken; and safety precautions that must be taken. The pupils will be given an instruction sheet. The teachers will be given background information about the experiment on Earth, and about the different directions they should guide the pupils in.

In the third part, the pupils will present the adjustments they think should be made to the experiment in space.

the preliminary experiments conducted by him and the lab team.

Supplies required

In the classroom: computer, projector and screen, instruction sheets for the pupils, lesson plan for the teacher, introductory video, and summarizing presentation

Preparing for the Activity

Before starting the activity, upload the introductory video and the summary presentation to the computer.

We recommend organizing the class in groups of up to five pupils. The class can be divided into activity groups in advance.

The Activity

Time	Part	Topic	Aids
5 minutes	Introduction	The pupils will watch a video introducing them to Prof. Moran Bercovici from the Technion, who will explain the experiment conducted in his lab on Earth. The scientist will explain why he wanted to attempt the experiment in space, describe the stages of the experiment, and ask the pupils to help him plan the experiment in space.	**Introductory video**
25 minutes	Discussion	The pupils will hold a discussion in groups on how substances behave in microgravity, on the elements that must be added or removed from the original experiment, supplies that must be taken, and safety precautions that must be taken. The pupils will summarize the conclusions from the discussion on an instruction sheet for the task.	**Pupil instruction sheet** includes a synopsis of the video they watched, and the questions that Prof. Bercovici asked the pupils. **Teacher's lesson plan** that states the points of difference

		if needed.	one that will be conducted in space.
35 minutes	Presentation	The pupils will present to the class the adjustments that they think should be made to the experiment in space.	At this stage, it's best to ask a representative from each group to present one element of the experiment that remains the same in space as on Earth, and one element in the experiment that changes. This way, all the groups can offer something new when they present. It's recommended to encourage a discussion **between** the groups during the presentation.
15 minutes	Summary	Using a presentation and pictures, tell the pupils about the experiment that Eytan Stibbe will perform, including: the supplies he brought with him, the preliminary experiments that he and the lab team conducted.	**The presentation on the liquid lens experiment – Eytan Stibbe**
10 minutes		Discussion and Reflection	**The lesson plan** will contain several questions to reflect on the process during the lesson, and how they feel about the Israeli astronaut's upcoming space mission.

Points of difference and similarity between the experiment on Earth and the one that will be conducted on the space station

To help with the summary and respond to the pupils' assumptions, a table is included that lists the changes that the experiment will undergo in microgravity in space versus the experiment that was conducted at the Technion on Earth.

the experimen t	**experiment on Earth?**	**space?**
Using a solution (water and glycerin)		In the experiment on Earth, the solution enables neutral buoyancy and resembles microgravity conditions. In the experiment in space, the solution will be unnecessary and the lens is expected to "float" in the air, just like in water.
Creating a smooth lens	The lens is created in the experiment because of the surface tension between the lens fluid and the buoyancy fluid surrounding it. Surface tension also exists between liquid and air (like a drop of water on the table will still be very smooth), and therefore we anticipate that the lens formed will be smooth even without the presence of a liquid surrounding it.	And yet… we don't know. The experiment in space is supposed to prove the expected hypothesis. What can differ, for example? Tremors can disrupt the lens' shape. When there is a buoyancy fluid surrounding the lens it acts to restrain (or reduce) and rapidly suppresses disturbances. Without the buoyancy fluid, disturbances may manifest more significantly on the surface.
A stand that stabilizes the ring into which the lens is poured		On Earth, weights are attached to the stand stabilizing the lens's frame, and they prevent it from floating in the solution. Weights won't help to stabilize the stand in space. The lens preparation stand also need to be stabilized in space. In space, things are stabilized mostly using hook and loop fasteners (such as Velcro), magnets (like fridge magnets), or rubber bands, which

The need to solidify the lens using UV radiation	To bring the lens to Earth, it will need to undergo polymerization and solidification using UV radiation.	In microgravity, the lens can be useful even without solidification. In this form, it is possible to create a folding space telescope with liquid lenses, for example.
Bubbles	Air bubbles that get accidentally trapped in the fluid damage the quality of the lens. The air density is significantly lower than that of the liquid, and therefore on Earth, the air bubbles float to the top of the container.	When there is no gravity, there is also no buoyancy. Bubbles that are trapped in the liquid will stay where they are. We must therefore be very careful not to accidentally introduce air bubbles.
Safety of liquids	The solution and the polymer are packaged in hermetically sealed bottles, both on Earth and in space.	On the international space lab, all liquids require double packaging. The current experiment will be triple packaged: The lens polymer will be in a bottle, the bottle in a sealed bag, and the entire experiment will be performed inside a closed and transparent flexible box that allows the person performing it to insert their hands and conduct the experiment without the risk of liquids or gases escaping into the space station. On Earth, if we "missed" during the injection process, the polymer drop would fall on the table and we could wipe it up with a cloth. Without gravity, the polymer drops will float around and it may be challenging to catch them and prevent them from reaching other sensitive equipment. Polymers sometimes carry an unpleasant odor (like glue). On Earth it's possible to open a window and air out the room, but on

		materials sent into space are neither hazardous nor smelly.
Closing boxes	The general structure of the experiment system resembles the one on Earth – the frame into which the polymer is injected and then closed with a lid that contains the ultraviolet light to stimulate the polymerization process.	On Earth, the lid remains closed because of its weight, and does not need to be locked. But in space there is no force that will hold the lid over the box if it is just placed on top. Therefore, it's important that each lid is fastened with hook and loop fasteners (Velcro) to keep it firmly in place.

As enrichment for the teacher and to assist the pupils and encourage discussion if needed, a presentation and video are enclosed explaining the physics of microgravity, where we encounter it in day-to-day life, and why it occurs on the International Space Station. Some of the links explain the novelty of experiments in space and water as a way of simulating microgravity. The materials are given as enrichment for the teacher, but they can also be used with the pupils and incorporated in the lesson.

What is gravity? What is microgravity? (Presentation – Ramon Foundation)

Microgravity: Brief explanatory video

How microgravity affects the human body (Davidson Institute website)

Why are experiments conducted in microgravity? (NASA)

Top 5 space experiments

Training astronauts in microgravity… in a pool! (NASA's Neutral Buoyancy Lab)

Summary and Reflection

A summary the offers space for reflection will enable the pupils to express what they think and feel about an Israeli astronaut's mission to space, and about how they experienced the learning process.

You can ask questions like:

How did you feel about an Israeli astronaut traveling to space?

What do you think about him conducting scientific experiments on the space station?

How did you feel about thinking about behavior in space and planning a scientific experiment in space?

Would you like to fly to space?

What experiment would you perform there?

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