In the spirit of NSLComm's NISSAN antenna experiment

Content: Materials Science | Technology | Mathematics (optional)

Age range: Elementary + Junior High School

Duration of the activity: Three lessons with the option of continuing with an online conversation with a scientist

Location of lesson: Classroom or workshop

Description of the activity

This activity combines teamwork that simulates the real challenges that R&D teams at tech companies must cope with when developing communication satellites. The activity begins with a discussion about satellites and what they're used for: What is a satellite, types of satellites, general structure, the role of the antenna. Then, each team gets a task card and supplies, and tackles a series of practical challenges in developing a satellite antenna. In the second lesson, the teams will present their preliminary results and conclusions to the class and raise questions pertaining to their attempts.

After the activity, it's recommended to schedule a conversation with an "online scientist": a conversation with a satellite specialist where the pupils can asks questions that emerged during the activity.

Rationale

While on the space station, Eytan Stibbe will conduct a test of one of the largest challenges in space – optimal deployment of a communication satellite antenna in microgravity conditions. The activity simulates coping with challenges in the process of developing antennas for satellites. The satellite antenna is what enables the back and forth transmission of broadcasts and information from Earth to space. This makes it an essential satellite component: Without antennas we wouldn't be able to conduct day-to-day activities like using a cell phone, navigating with Waze, and more.

Objectives

- To learn about what a satellite is; what types of satellites we use, and why they are important to us.
- To demonstrate challenges faced by satellite development teams.
- To try and tackle a complex challenge using teamwork.
- To present in front of an audience.

Key concepts

Satellite, antenna, data reception and transmission, area, mathematical ratio, material, stability, teamwork, development.

The Nature of the Activity

In-person teaching | Hands-on learning | Exploratory learning | Teamwork

Supplies required

- Materials for building an A3-sized dish antenna (approx. 30 cm x 40 cm): Sheet of paper, Bristol board, parchment paper, different fabrics, Ethylene-vinyl acetate (EVA), tinfoil, clingwrap, nylon, and more
- Scissors
- Measuring tape / ruler
- Wooden sticks the size of skewers (three per group)
- Plasticine (to stand the sticks upright)
- Adhesive tape (Sellotape)
- Rubber bands
- Sheets of paper and writing utensils to write questions raised by the teams during the activity
- A board or large sheet of paper and marker to record all the questions the teams raise
- Task and information sheet

Preparing for the activity

- Bring different materials to use when experimenting with constructing the dish antenna. A detailed list of recommended materials can be found in the "supplies" section. You can also ask the pupils to bring materials from home.
- Download the task pages from the website and print one for each group.
- Divide the pupils into six teams.
- Organize the class to accommodate a six-group activity.

- See accompanying presentation
- We recommend using a board or large sheet of paper to write questions that the pupils raise during the activity and to address them in the summary.

1. (5 minutes) Introduction: Video on deploying a satellite antenna in space
   - Two links to the same video:
     - On the NSL home website https://www.nslcomm.com/home The video starts a few seconds in.
     - On YouTube: https://www.youtube.com/watch?v=zyQoKf4XRyY

2. (20 minutes) Briefing the R&D teams
   - **Presentation: General information about satellites**
     - What is a satellite?
     - Natural and artificial satellites
     - Examples of human-made satellites and their different uses: reconnaisance, communications, weather, monitoring air and land data, astronomy (telescopes) and positioning (GPS)
     - Israel and satellites
     - Satellite structure
     - The antenna – structure and role
   - **Presenting the framework story for the task**
     A video where Iddo Dagan, Head of NSLComm's Antenna R&D Team, recruits the pupils to the task, explains the challenges, and gives them his blessing.
     Link to the video.
   - **Getting to work**

3. (50 minutes) Work in teams

The pupils will receive a card that contains concise information about the satellite, the antenna, and the challenges during the launch and space stages. As a team in a satellite antenna company responsible for prioritizing and recommending a suitable material for the antenna, the teams will be asked to tackles the challenges while testing the materials at their disposal.

Suggestions for conducting the work in teams

are fine, of course, and it's best to give an explicit explanation of the choice. You can also discuss the pros and cons of each way.

- The tasks can be divided into stages for the sake of practicing schedules and deadlines. It's best to remind the whole class, or each team separately, of the schedule, depending on the composition of the teams and the way they have chosen to work.
- Pay attention to the strategies the different teams chose, and use them as examples in the discussion and summary.
- The pupils will be asked to write questions that come up in their group during the work. These questions may pertain to a wide variety of topics, like the role of the satellite, the antenna and the materials, the work of the scientists and engineers, and the feelings the team experienced (frustration, success, etc.).

Description of the task on the card:

(20 minutes) **Part A: Test what the most suitable material is for constructing an antenna**

The material you'll recommend for constructing the antenna must match all stages of the task as best as possible. Criteria for selecting the material:

- **The launch:** The antenna must be able to fold into a small box attached to the satellite.

  You must find the material that folds the most efficiently. You'll need to fold as much surface area as possible inside as small a box as possible. The challenge may include different ways of folding, and finding the most effective way to fold.

  For a more advanced task you can propose a numerical index:

  - Measure the diameter of the unfolded "antenna".
  - Measure the lengths of the components of the folded surface.
  - Divide the diameter by the length of the component, then calculate the areas and divide the unfolded antenna area by the area of the folded antenna.

  This will give us a numerical index of the task's success. The higher the ratio, the greater the success.

- **Opening in space: Flexibility and returning to its original shape.**
  You must find the material that can return to its original shape with the greatest ease.
- **Operation in space:** Long-term stability while open.

(15 minutes) **Part B: Making a decision**

After the prioritization stage, you have to come to a decision: Which material are you choosing for the antenna?

Decide which material best meets all three criteria, and give a brief explanation of your choice.

(15 minutes) **Part C: Preparing a presentation of the final product**

4. (30 minutes) Presenting the final products to the class

   Each group has three minutes to present their experience, the challenges they faced, and the final product.

   Please pay attention to the following points when presenting:

   - What criterion did each group pay more attention to?
   - What criterion did they manage to address better?

5. (20 minutes) Discussion

   Questions for discussion:

   - Is it possible to combine solutions from different groups in order to find the best solution?
   - What did you discover that you didn't previously know, or that you hadn't thought of before?
   - What was most frustrating?
   - If you were to invent a new material for antennas, what properties would you want it to have? Give it a name and description.
   - Is folding the only suitable method for the task? Or perhaps rolling or something else is better?
   - Was your experiment compatible with the conditions in space, like zero gravity? What is the advantage in space? What is the disadvantage?
   - What additional challenges are there to contend with? (The antenna's resistance to heat, cold, zero gravity | The antenna's unfolding mechanism | Constructing a suitable box, and more.)
   - Did the teamwork help you?

6. (10 minutes) Summary

   - A video where Iddo Dagan, Head of NSLComm's Antenna R&D Team, talks about their solution and about the experiment aboard the space station.

- Collecting questions that were raised during the work, the discussion, and the summary:
    - Option A: To invite Iddo or other engineers to a conversation with an "online scientist".
    - Option B: To select one or two questions and email them to the Davidson Institute: davidson@weizmann.ac.il

Final Products

Models constructed from the selected materials.

A list of questions that the pupils want to pose to an expert.

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