Caution - Contamination!

Metadata

General Info

Title

Caution - Contamination!

Short description

You are probably aware that contamination plays a big role down here on earth. There is a lot of newspaper coverage about contamination of our water and soil. Believe it or not, contamination even plays a role if we want to visit Mars! According to the Outer Space Treaty from 1967, Earth and other planets have to be preserved from contamination. Research on contamination of space vehicles before launch has been done before. In this activity, we will investigate how contamination spreads as we explore new worlds.

Keywords

Contamination, propagation, optimization, hands-on activity.

Educational Context

Context

Student centered problem-based learning, interdisciplinary activities, collaboration

Age

At the secondary level, the appropriate age level depends on how much mathematics is included in the optimization calculations and can be chosen flexibly.

Prerequisites

None.

Lv. Of difficulty

Varies with amount of mathematics that should be included.

Duration

3 hrs max

Educational Objective

Create an educational framework with the goal to challenge our students and start the process of inquiry-based learning. The applicability of this approach extends to many subjects in the STEAM arena.

Cognitive Objectives

The focus is on a scientific, practical experiment.

Affective

Promoting group work.

Psychomotor

The experiment could easily be extended to include more or less psychomotor challenges for students.

Subject Domain

A topic that can be easily integrated into all STEAM subjects.

Big Ideas of Science

Pollution of water and soil is a major problem that affects us all, especially young people, because they will inherit the planet and have to cope with the pollution that has already occurred. Science in schools can do much to raise awareness of this problem. Problem-based learning could be the key to engaging our students in this important process.

Subject Domain

There is an obvious connection to biology, physics, chemistry and mathematics. Even computer science could be integrated into the task at hand - but there probably won't be enough time to do all the visualizations that would be possible.

Orienting & Asking Questions

You know this man - he walks around and drops all his trash. We're not going to count all the cigarette butts and chewing gum in St. Mark's Square in Venice. You've heard about the problem of microplastics in the ocean. And after the years of the pandemic, you are well aware of the spread of a virus. But did you know that pollution also plays a big role in space exploration? You've probably heard about space debris and how it poses a danger to satellites in orbit. But there is another issue: the pollution of planets and moons in our solar system. It is mentioned in the Outer Space Treaty, which was written quite a long time ago.

In this activity, we're going to look at how germs spread as we move across a planet. First, look at some of the topics above (e.g., microplastics in the ocean, trash in space, or the Outer Space Treaty). And don't forget to visit the website of the Austrian Space Forum - because they report some real experiments on contamination. For this task you could search the net for AMADEE 20 and the "Micro-Potential" experiment. I am looking forward to your results!

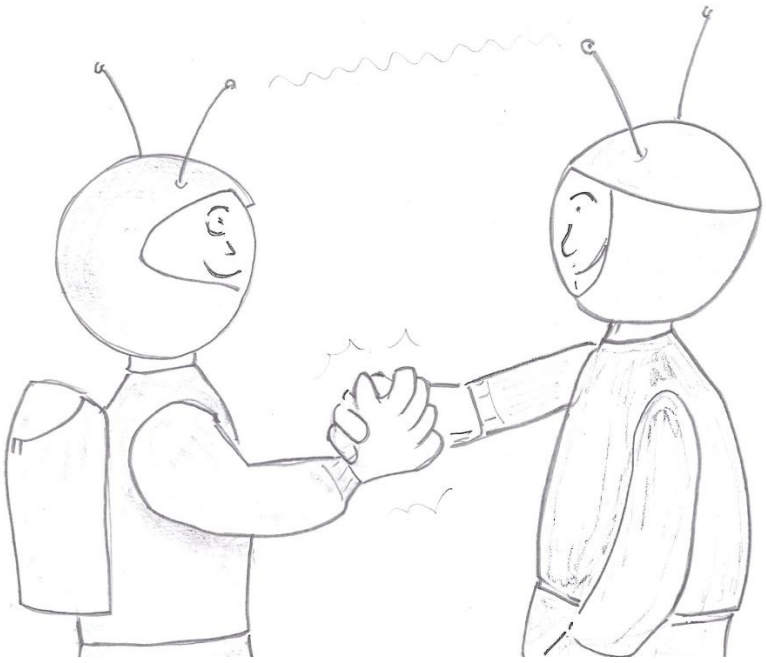
Out of self-interest: How would you estimate the amount of spit out gum in a tourist spot near you? In this respect, St. Mark's Square in Venice is no better than any other tourist spot near you. And do you think there is a correlation between the amount of gum on the floor and the popularity of the place? If so, which one?

Hypothesis Generation and Design

Imagine the following experiment: 20 children stand in a row. The first child in the row puts his hands into a pot of mud. Then he turns around and shakes hands with the second child in the row. Now the second child turns around and shakes hands with the third child, and so on. How far would the mud spread in the row with the children? And what if some children shake hands under water? Is shaking hands under water crucial to the outcome of the experiment?

Now let's see how far germs spread if we contaminate the tires of a toy car (perhaps one that can be controlled remotely, like a Mars rover) with a special substance. Let's try contaminating the tires with a special substance that can only be seen under ultraviolet light. That would add to the surprise. Maybe your teacher already has such a substance in her hand!

Does it make a difference on which ground the car is driving?



Planning and Investigation

You will perform two experiments on the topic of the spread of germs:

First, the linear version:

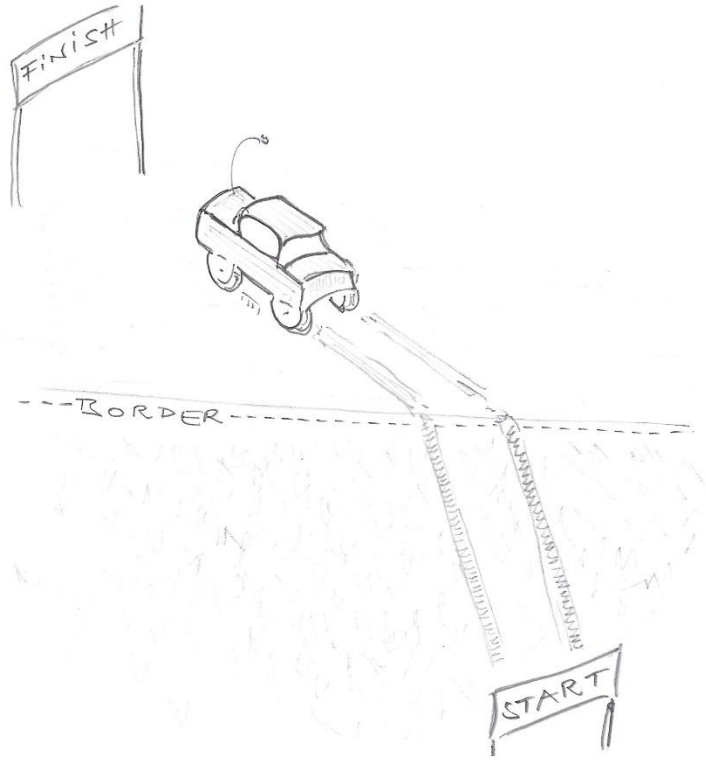
Contaminate the tires of your toy vehicle with a special substance and drive on different surfaces. How far will the substance spread during the driving distance? Measure the distance over which the contamination can be detected.

Second, the version with a boundary line:

There is a famous problem: A student has a summer job as a lifeguard at the beach. After spotting a swimmer in trouble he tries to deduce the path by which he can reach the swimmer in the shortest time? You know you can't swim as fast as you can run on the sandy bottom of the beach. At what point would you enter the sea?

Now consider a similar experiment with your contaminated rover. First, find a terrain with two different surfaces - say sand on one side of the boundary and asphalt on the other side of the boundary line. With your contaminated tires, you need to start on the sandy side of the boundary and reach the destination, which is on the asphalt (see sketch below). At what point would you cross the boundary between sand and asphalt?

Do you recognize the similarity between the lifeguard's problem and your problem? What will happen when the sand is wet?


FINISH
BORDER
START

Analysis & Interpretation

It is not so easy to see in the experiment above at which point the contamination of the soil disappears. Doing scientific research often means making things simpler and, above all, controllable.

In many cases, this means developing a model: so you don't build the real thing - but something that captures the important features of the real thing. For example, an architect would make a model of a bridge to see if the bridge would collapse or not. To do this with a real bridge would be crazy. The color of the model bridge doesn't matter here - but the number of supports does.

So let's also create a model of our situation and analyze it thoroughly:

To contaminate the ground would be to scatter something as you walk. You can do this by preparing a salt shaker that you carry with you. The easiest way is to make holes in the bottom of a plastic bottle. Fill the bottle with sand, and as you walk around, the sand will stain the ground as it falls through the holes directly onto the ground. Now you can build a second bottle with larger (or more) holes: This will model a situation where the pollution of the environment is even greater.

Now you can do the experiment where the goal is to find the right point to cross the line between two different surfaces - one where more contamination was left and one where less contamination was left (just use the bottle with the small holes on one side of the border and the bottle with the bigger holes on the other side of the border). Make sure you run at the same speed - otherwise the comparison would not be fair.

Conclusion & Evaluation

Finally, when you report your findings, you should also include a chapter on theory. Often this is the starting point for a research project. In your case, the theory has to do with the problem of how impurities on one object are transferred to another object. That has a lot to do with surface physics. But to put it simply: It's also why we heard so much about hand washing during the pandemic years. How can something be transmitted even if there is no physical contact.

This is also the idea of a stamp. Take two items (paper and stamp) and observe how much stuff is transferred. Now change only one thing (try soapy water on a blotting paper instead of regular paper), leaving all other conditions unchanged.

All of this is another way of looking at your crossing-the-line experiment with contaminated tires. Here in the final part of your paper is the right place to put your work together so that everything in it, everything about it, fits together.

I'm looking forward to reading your report!


MISSION
COMPLETED

Background Information for the Teacher:

It can be beneficial to tie the beginning of the activity into a story. The overarching arc for the story is the issue of pollution, which affects more than just the environment on Earth. One can borrow from the Outer Space Treaty from 1967 to make the connection with pollution on other planets. The Austrian Space Forum also led an experiment as part of an analog mission that related to the pollution of a planet as it occurs in the exploration of Mars, with or without astronauts. Background on this research project can be found on the Austrian Space Forum website. Look up AMADEE 20, the latest analog Mars field mission in the Negev Desert, and see the MICRO-POTENTIALS experiment. This experiment was conducted in collaboration with Tel Aviv University and the Weizmann Institute of Science in Israel:
https://oewf.org/en/amadee-20/

For the proposed experiments, you can also use invisible germs. This powder can be easily obtained on the Internet: Just type "germ powder for school use" into a search engine.

For older students you can also deal with the calculation. The calculation would introduce you to the topic of optimization (and address the question of at what point to cross a boundary line that separates different environments - a classic optimization problem - usually the speed of the lifeguard varies in different environments - here we will have different contamination rates, but the rest of the calculation would be quite similar).