



Pulsars, Stars and Heat – VEGA Teaching Scenario

Topic: Getting to know pulsars, stars and how heat plays a role in the universe.

Subject(s): Physics / Astronomy / English

Age / Grade: 11+ / grade 5+

Short description of the VR game in this scenario:

[Universe Sandbox](#) is a space simulator that merges real-time gravity, climate, collision, and material interactions to reveal the beauty of our universe and the fragility of our planet. Includes VR support for HTC Vive, Oculus Rift+Touch, and Windows Mixed Reality.

Introduction to the scenario

In this scenario students further learn about celestial objects, namely pulsars and stars. Students also investigate and study the heat of different kinds of planetary objects, particularly in our own Solar System. This scenario also features a freeform section where students get to explore the universe on their own.

Learning outcomes:

The students are able to:

- to learn more about pulsars, stars and heat
- study celestial objects and influence them in *Universe Sandbox*
- to experiment with celestial objects in *Universe Sandbox*

A selection of learning outcomes from the Finnish Curriculum

- M1 arouse and maintain the student's interest in the environment and the teaching of environmental science and help the student to realize that all subject areas in environmental science are important for him
- M2 guide and encourage the student to set goals for their studies and to work long-term to achieve them and to analyze their knowledge in environmental science
- M3 support the student to develop environmental awareness and to act and influence in their immediate environment and in different contexts to promote sustainable development and to appreciate the importance of sustainable development for themselves and the world
- M4 encourage the student to formulate questions on different subject areas and to use them as a starting point for investigations and other activities
- M5 help the student to plan and carry out small investigations, make observations and measurements in diverse learning environments with the help of different senses and investigation and measurement tools
- M6 help the student to see the connection between cause and effect, draw conclusions based on the results and per center their results and research in different ways
- M13 guide the student to understand, use and create different models with the help of which one can interpret and explain man, the environment and related phenomena
- M15 guide the student to investigate nature , identify organisms and habitats, think ecologically and help the student to understand human structure, life functions and development
- M19 guide the student to understand the areas of health, the importance of healthy habits and the course of life, the individual growth and development in childhood and adolescence and encourage the student to practice and apply their knowledge on health in everyday life

Formative assessment

Number of students: Duration (estimated time/number of lessons):

- 20 students (4 students/group)
- 2 lessons á 45 min

Prerequisites (necessary materials and online resources):

- Computers with internet connection and Universe Sandbox downloaded on a STEAM account
- VR glasses with the application installed on a gaming computer (Valve Index, Oculus Rift or some other VR Goggles connected to STEAM) **(optional but highly recommended)**
- Check that the internet is working
- Information about the topic to mediate to the students (videos, pictures, Educational tools etc.)

Before the program begins (preparatory work for teacher):

- Search and collect information and material about the topic
- get properly acquainted with the app Universe Sandbox and the demo version on computer
- Prepare and collect all things needed for the scenario
- Learn how basic functions work and how you use the controllers (make a manual for the controllers if the students haven't used them before)
- Create an assignment in Google classroom with project description and goals (the same task for two lessons)

All material the students need is included in the assignment

- Divide students into groups of up to four students

The main part of the scenario (number of lessons):

Part One: Pulsars and Stars (one lesson 1 x 45 min)

- The teacher divides the students into small groups (up to 4 per group). Each group needs access to their own computer with Universe Sandbox.
 - This lesson has the students learn and explore the concept of **pulsars** and **stars**.
1. Divide the students into small groups, each with their own computer with Universe Sandbox.
 2. Go through the theory below ([source](#)) and/or your own notes on the topic with the students.
 - Pulsars are spherical, compact objects that are about the size of a large city but contain **more mass than the Sun**.
 - Scientists are using pulsars to study **extreme states of matter**, **search for planets** beyond Earth's solar system and **measure cosmic distances**.
 - Pulsars radiate two steady, **narrow beams of light in opposite directions**. Although the light from the beam is steady, pulsars appear to flicker because they also spin.
 - Over 2,000 pulsars have been detected in total. ([Some of them listed here!](#))
 - Pulsars **aren't really stars** — or at least they aren't "living" stars. Pulsars belong to a family of objects called neutron stars that form when a star more massive than the sun runs out of fuel in its core and collapses in on itself.

3. VR assignment: **Binary Pulsar.**

- Open the simulation **Binary Pulsar.**
- (You may wish to slow down or stop the simulation, as the pulsing of the pulsars can be quite annoying.)
- How hot are the pulsars? A: Immensely hot! Almost 1.5 million Celsius.
- What are they composed of? A: Nothing but Hydrogen.

4. VR assignment: **Solar System and Pulsar.**

- Open the simulation **Solar System.**
- Replace Venus with a **Monogem Pulsar.**
- What happens? A: All the object in our Solar System are catapulted away because the pulsar has more mass than the Sun.

5. Go through the theory below ([source](#)) and/or your own notes on the topic with the students.

- **Stars are the most widely recognized astronomical objects**, and represent the most fundamental building blocks of galaxies.
- Stars are responsible for **the manufacture and distribution of heavy elements** such as carbon, nitrogen, and oxygen, and their characteristics are intimately tied to the characteristics of the planetary systems that may coalesce about them.
- **Stars are born within the clouds of dust and scattered throughout most galaxies.** As the cloud collapses, a dense, hot core forms and begins gathering dust and gas. Not all of this material ends up as part of a star — the remaining dust can become planets, asteroids, or comets or may remain as dust.

- Stars are fueled by the nuclear fusion of hydrogen to form helium deep in their interiors. The outflow of energy from the central regions of the star provides the pressure necessary to keep the star from collapsing under its own weight, and the energy by which it shines.
- In general, the larger a star, the shorter its life, although all but the most massive stars live for billions of years. When a star has fused all the hydrogen in its core, nuclear reactions cease.

6. VR assignment: **Star Swarm.**

- Open the simulation **Star Swarm.**
- Observe. What happens? A: Multiple supernovae are triggered by the collisions.

7. VR assignment: **50 brightest stars.**

- Open the simulation **50 brightest stars.**
- What impacts brightness? A: Temperature and distance to the observer.

8. (Bonus) Watch these videos on stars with your students:

- [National Geographic: A Hundred Million Stars in 3 Minutes](#) (4 min)
- [NASA | Massive Black Hole Shreds Passing Star](#) (1 min)
- [Stars 101 | National Geographic](#) (3 min)

Part Two: Heat and Freeform Simulation (one lesson 1 x 45 min)

- The teacher divides the students into small groups (up to 4 per group). Each group needs access to their own computer with Universe Sandbox.
 - This lesson has the students learn and explore the concept of **heat**.
1. (Optional) Watch these videos on heat with the students:
 - [NASA | Aqua CERES: Tracking Earth's Heat Balance](#) (4 min)
 - [NASA Spotlight: Heat and Temperature](#) (2 min)
 - [NASA | The Ocean: A Driving Force for Weather and Climate](#) (6 min)
 2. VR Assignment: **Earth at different degrees Celsius.**
 - Study the “Earth at X degrees” simulations in order. There are nine of these simulations (Earth at 500 degrees Celsius, Earth at 1000 degrees Celsius, etc.)
 - Why don't the oceans immediately boil away at 500 degrees? A: It takes time to boil away such a large amount of water.
 - Why does Earth slowly cool when it is heated to these extreme temperatures? A: The heat is lost into space.
 - What happens when the temperature is at least 20 000 degrees Celsius in the simulation? A: Earth is vaporized completely, immediately.

3. VR Assignment: **Heat in our Solar System.**

- Open the simulation **Our Solar System.**
- Study Venus and Mercury. Mercury is closer to the Sun than Venus. Why is Venus hotter? A: Venus' cloud layers and immense carbon dioxide cause a runaway greenhouse effect that traps heat - an extreme version of the greenhouse effect on Earth.
- Observe Mars. Why does its temperature change so much? A: The absence of water makes the temperature on [Mars change a lot.](#)

4. VR assignment: **Tidally locked Earth.**

- Open the simulation **Tidally locked Earth.**
- What happens if you speed up the simulation and wait long enough (such as 20 years)? A: The dark side of Earth will freeze completely.
- Can you think of a celestial object that is tidally locked? A: The Earth's Moon is a tidally locked object - the dark side of the Moon is never seen from Earth!

5. (Bonus) Freeform simulations: Students explore interesting simulations at their own leisure. Here are some interesting ones:

- Solar System with Betelgeuse instead of Sun
- Ultimate Engineered Solar System
- Solar System with no Sun
- Earth exploding in RealTime
- Collapsing Momentum Test

6. DEBRIEFING - questions for each student individually

- How are pulsars not really stars? A: They're not truly living stars. Pulsars belong to a family of objects called neutron stars that form when a star more massive than the sun runs out of fuel in its core and collapses in on itself.
- How long do stars live? A: Billions of years.
- What effects does tidal locking have? A: Drastically different temperatures on the dark and bright sides of the planet.

Summative assessment:

Grades 5-10	5	6	7	8	9	10
Activity and engagement	The student has had challenges to get the task finished. The student hasn't shown signs of engagement neither at school nor at home.	The student has only occasionally shown interest in the work and has had difficulty finding motivation.	The student has mostly shown interest in the work both at home and at school.	The student has shown interest and commitment to the work both at home and at school.	The student has shown great interest and commitment both in lessons and at home.	The student has shown great interest, responsibility and commitment both in lessons and at home.
The overall picture of the work when completed.	The student misses several parts of his work and several points are not checked in the list.	The student lacks several parts of the checklist in his work.	The student lacks certain parts of the checklist, but it is largely complete.	The student has done all the parts on the checklist.	The student has done all the parts on the checklist and you can see that the student has made an effort to include all the parts.	The student has done every single part on the checklist and it can be seen that the student has processed the content.
Images and captions	The student lacks pictures.	The student has few pictures and no captions.	The student has pictures but no captions.	The student has pictures with accompanying text.	The student has several pictures and descriptive captions.	The student has versatile pictures and descriptive and explanatory text.

<p>Showing responsibility for the completion of the work. Cooperation and peer response</p>	<p>The student had difficulty cooperating with his group and did not listen to his classmates. The student did not give a peer response and did not take into account what the group gave in response.</p>	<p>The student had some difficulties in cooperating with his group and listening to his classmates. The student gave peer feedback without following the instructions. The student did not take into account the response given by the group.</p>	<p>The student mostly cooperated well with his group. The student received and gave feedback from his group almost always according to the instructions. The response was mostly constructive.</p>	<p>The student showed responsibility and mostly a good ability for cooperation. The student received and gave feedback from his group. The response was constructive.</p>	<p>The student showed evidence of good responsibility and a good ability for cooperation. The student gave a versatile response and took the response he / she received from his / her group into account.</p>	<p>The student showed evidence of excellent responsibility and an excellent ability for cooperation. The student made an effort to formulate himself in a constructive and valuable way for the task in order to help his group further in his work. The student received a response from his group and took it into account in his own work.</p>
<p>Skills</p>	<p>The student shows obvious shortcomings in the understanding of the subject.</p>	<p>The student shows some shortcomings in the understanding of the subject.</p>	<p>The student shows evidence of a certain understanding and some learned knowledge of the subject. .</p>	<p>The student shows evidence of a good understanding and has assimilated the most important content in the subject.</p>	<p>The student shows an excellent understanding and has assimilated the most important content in the subject but lacks some knowledge.</p>	<p>The student shows evidence of an excellent understanding and fully masters the content.</p>

Language learning/English	The student has big difficulties in learning the English words.	The student struggles with and has some challenges with the English words.	The student knows the most important concepts and words in English.	The student shows evidence of understanding most parts In English.	The student has a good understanding and has learned most of the concepts and knows all the words in English.	The student masters all concepts and words in English.
The VR part and the app use	The student presents obvious difficulties in understanding how the Universe Sandbox app works. Shows a lack of interest and is careless in the use of equipment needed.	The student presents some difficulties in understanding how the Universe Sandbox app works. Trying to follow the instructions, but can not keep the interest up all the time. The student is sometimes careless in the use of equipment needed.	The student understands the main features of how the Universe Sandbox app works. Mostly follows the instructions, but sometimes lacks perseverance. Is usually careful with the equipment.	The student shows a good understanding of how the Universe Sandbox app works. The student always follows the teacher's instructions and is careful with equipment.	The student shows an excellent understanding of how the Universe Sandbox app works. Always follow the teacher's instructions and be very careful with the equipment.	The student masters the use of the Universe Sandbox app. Always follow the teacher's instructions and help their classmates. Always be careful with technology.