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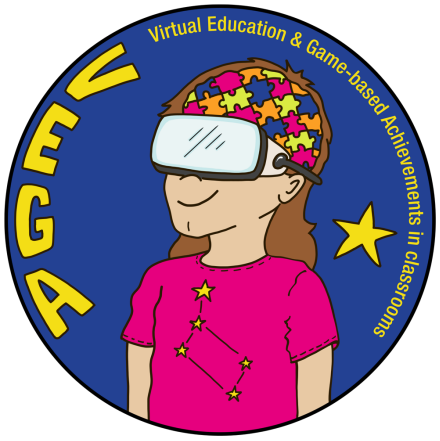

Black Holes and Supernovae – VEGA Teaching Scenario

Topic: Getting to know black holes and supernovae and their effects on planetary bodies near them and the life cycles of these celestial bodies.

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 learn more about two celestial phenomena: black holes and supernovae. The students get to experiment with adding both kinds of objects to galaxies and how they interact with their surroundings. In the future, it may be possible that black holes (and perhaps even supernovae) can be immense sources of usable energy, and black holes are now used to map locations of the universe, as they can be used to find the mass of any body around which another object orbits.

Learning outcomes:

The students are able to:

- to learn what exactly black holes and supernovae are
- the potential uses of both black holes and supernovae
- see the effect of black holes and supernovae on other celestial objects
- to experiment with black holes and supernovae 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

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: Black Holes (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 **black holes.**

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.

- A black hole is a place in space where **gravity pulls so much that even light can not get out**. The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.
- Black holes are **invisible because light cannot escape them.**
- Black holes can be big or small. Scientists think **the smallest black holes are as small as just one atom**. These black holes are very tiny but have **the mass of a large mountain.**
- The largest black holes are called "**supermassive**." These black holes have masses that are more than 1 million suns together. Scientists have found proof that **every large galaxy contains a supermassive black hole at its center**. The supermassive black hole at the center of the Milky Way galaxy (our galaxy) is called **Sagittarius A**.
- Scientists think supermassive black holes were **made at the same time as the galaxy they are in**.
- Could a black hole destroy the Earth? No. **Black holes do not go around in space eating stars, moons and planets**. Earth will not fall into a black hole because no black hole is close enough to the solar system for Earth to do that.
- Even if a black hole the same mass as the sun were to take the place of the sun, **Earth still would not fall in.** The black hole would have the same gravity as the sun. Earth and the other planets would orbit the black hole as they orbit the sun now.

3. VR assignment: **Replace the Sun (of our Solar System) with a black hole with the same mass as the sun.** What happens? Give the students time to observe our galaxy after doing this.

   Expected answers

   - The planetary bodies´ trajectories are not affected at all. Since the black hole has the same mass as the Sun it replaced, superficially everything else is the same.
   - Without the heat from the Sun, **Earth's temperature will begin to drop.**
   - Other bodies will also begin cooling down but at variable speeds. **Venus takes a long time to cool down due to its strong greenhouse effects.**

4. VR assignment: Take a look at a black hole.
   - Have students open the simulation **Black Hole & Sun.**
   - Zoom into the black hole. What does it look like? (HINT: Pause the simulation, select the sun, and then select the black hole from the Sun´s “orbits” section). A: nothing but black and also an aura that distorts light around it
   - What is the black hole composed of? A: Hydrogen
   - What eventually happens to the Sun if you let the simulation run long enough? This typically takes 10-15 days. A: The Sun is completely destroyed.

5. VR assignment: **Destroy a black hole.**
    - Open any simulation which includes a black hole or add a black hole to an existing simulation.
    - Launch huge objects at the black hole. What does this do? A: Nothing except increase the density of the black hole.
    - Try changing the material densities of the black hole. What does that do? A: Nothing at all.
    - It might be possible to destroy a black hole, but this has never been attempted (and the effects of destroying one are unknown).

6. (Bonus) Videos:
    - Black Holes 101 | National Geographic (3 min)
    - Veritasium: First Image of a Black Hole! (6 min)

7. (Bonus) Theory: could black holes have potential uses?
    - BBC Future: Could we harness power from black holes?
    - National Science Foundation: Could we harness energy from black holes?
    - Astronomy.com: Could we steal energy from leaking black holes?

8. (Bonus): Astronomy.com: The Beginning to the End of the Universe: How black holes die

<u>Part Two: Supernovae</u> (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 **supernovae.**

1. Go through the theory below (source) and/or your own notes on the topic with the students.
    - **A supernova is the explosion of a star.** It is the largest explosion that takes place in space.
    - **Supernovas are often seen in other galaxies**. But supernovas are difficult to see in our own Milky Way galaxy because dust blocks our view. In 1604, Johannes Kepler discovered the last observed supernova in the Milky Way.
    - **A supernova happens where there is a change in the core**, or center, of a star. A change can occur in two different ways, with both resulting in a supernova.
        - The first type of supernova happens in **binary star systems**. Binary stars are two stars that orbit the same point. One of the stars, a carbon-oxygen white dwarf, steals matter from its companion star. Eventually, the white dwarf accumulates too much matter. Having too much matter causes the star to explode, resulting in a supernova.
        - The second type of supernova occurs at **the end of a single star's lifetime**. As the star runs out of nuclear fuel, some of its mass flows into its core. Eventually, the core is so heavy that it cannot withstand its own gravitational force. The core collapses, which results in the giant explosion of a supernova.
    - Scientists also have determined that **supernovas play a key role in distributing elements throughout the universe**. When the star explodes, it shoots elements and debris into space.

- **NASA scientists use different types of telescopes to look for and study supernovas**. Some telescopes are used to observe the visible light from the explosion. Others record data from the X-rays and gamma rays that are also produced.

2. VR assignment: **Supernova Closeup in Real Time.**
    - Open the simulation Supernova Closeup in Real Time.
    - Observe the simulation. The students can speed up the simulation.
    - What happens? A: The supernova keeps on expanding.

3. VR assignment: **Supernova the Sun in Solar System.**
    - Open the simulation Supernova the Sun in Solar System.
    - Observe the simulation. Ask the students: what happens to the planets? A: Mercury, Venus and Earth are completely destroyed, as are most moons, and all the other planets are heavily damaged by the supernova.
    - Open the slow motion version of Supernova the Sun in Solar System and observe the explosion and destruction of the Solar System.

4. VR assignment: **Type Ia Supernova.**
    - Open the simulation Type Ia Supernova.
    - Observe the simulation.

5. Classroom discussion:
    - Could our Sun ever go supernova? A: No. It does not have sufficient mass.
    - Why are supernovae important? A: They play a key role in distributing materials across the universe.
    - What else did you learn about supernovae?

6. (Bonus) Additional videos:
    - NASA Video: Zoom to Fading Supernova in NGC 2525 (1 min)
    - NASA | Fermi Proves Supernova Remnants Produce Cosmic Rays (4 min)

7. DEBRIEFING - questions for each student individually
    - Why is Venus so incredibly hot? A: It has a powerful greenhouse effect due to its atmosphere.
    - What exactly is a supernova? A: An explosion of a star.
    - What happens if you replace our Sun with a black hole that has the same mass? A: Nothing, except the heat of the Sun is lost.

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.

Showing responsibility for the completion of the work. Cooperation and peer response	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.	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.	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.	The student showed responsibility and mostly a good ability for cooperation.The student received and gave feedback from his group. The response was constructive.	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.	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.
Skills	The student shows obvious shortcomings in the understanding of the subject.	The student shows some shortcomings in the understanding of the subject.	The student shows evidence of a certain understanding and some learned knowledge of the subject. .	The student shows evidence of a good understanding and has assimilated the most important content in the subject.	The student shows of an excellent understanding and has assimilated the most important content in the subject but lacks some knowledge.	The student shows evidence of an excellent understanding and fully masters the content.

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 do according to 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 is 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.