



Final Discover the COSMOS Demonstrators

Impact Earth

Name of your Institution: University of Glamorgan
Title of the educational scenario template: Inquiry-based teaching
Title of your educational scenario: Investigating impacts from space

Educational problem:

When we look up at the Moon, we see a surface covered in craters, evidence that this Solar System object has been bombarded by impactors - but has the same happened here on Earth? How many times has the Earth been hit by space debris in the past and what is the possibility that we will be hit again in the future? What sort of objects strike us, and what effect does this have on life on Earth?

To answer these questions, we need to study the known impact craters on Earth, and use computer simulations to reproduce these impacts and investigate the types of impacting objects which produced these craters.

It is not feasible to travel to the sites of impact craters, but there are many tools available for students to be able to study them in their classrooms. By analyzing satellite images of impact craters on Earth, students can investigate the size of craters and comparisons can be made with distances local to their school or home. By then using an online impact simulator which is based upon the mathematics developed by research scientists in this field, they can change the size, velocity, and density of impactor, along with the angle of impact and other important parameters, and try to reproduce the impact craters which they have found in the images.

Educational scenario objectives:

During this scenario, students will:

1. Learn about impact craters
2. Learn about the types of objects which collide with Earth
3. Learn about the effects of impacts on life on Earth



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Characteristics and needs of students:

The scenario helps students understand how space can affect life on Earth. Students will be guided through how to use Google Earth to search for known impact craters and make measurements to determine their size. They will then use an online impact simulator to try and reproduce these craters. This gives students the possibility to draw conclusions about the types of objects which may have hit the Earth in the past, and how these impacts would have affected life on Earth at that time.

The measurements will also allow students to interact (e.g. by working in pairs) and develop social and collaboration skills, allowing them to see that science can be a group activity and not a solitary one. The experience from working like a “real scientist” may trigger an increased awareness of science in many of them, and possibly an interest in future science careers.

Rationale of the educational approach and parameters guaranteeing its implementation:

This scenario is structured upon the phases prescribed for inquiry-based learning and allows students to make their own discoveries, albeit in a structured and guided way. During the scenario the students assume the role of a scientist and work with real data from satellites, and a research-driven simulator, thus gaining a first-hand understanding of scientific inquiry.

For the implementation of this scenario students must have access to PCs (which should also be connected to the Internet) and Google Earth.

Learning activities:

Phase 1: Question eliciting activities

Exhibit curiosity

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You may begin your lesson with a presentation or video on impacts from space to introduce the students to the topic. Clips from popular films such as 'Armageddon' and 'Deep Impact' could be used as a starting point, as students will likely be familiar with these and trigger a conversation with the class as they discuss what has happened in the clips. You could encourage this discussion further by asking your students what they know about impacts and their effects on Earth in general.

You can then let your students know about what they will do during this exercise:

- Learn how to use Google Earth to find known impact craters
- Measure the extent of impact craters in Google Earth
- Investigate the effect of impacts using the online 'Impact Calculator'

Define questions from current knowledge

During your discussion with your students make sure that you ask them some of the following questions. This will both engage them further and check how much background knowledge they have on the subject.

- a) How frequently does space material bombard the Earth?
- b) What types of objects strike the Earth? Where do they come from?
- c) Have we been hit in the past? What is the evidence for this?
- d) How do impacts affect life on Earth?
- e) What happened to the dinosaurs 65 million years ago?
- f) Why are impacts from space important to us?

Phase 2: Active investigation

Propose preliminary explanations or hypotheses

For over 100 million years, dinosaurs reigned supreme over all animals on Earth, but a global catastrophe 65 million years ago wiped them off the face of the planet forever. Their sudden disappearance from the fossil record sparked much debate amongst scientists as they tried to piece together the clues for their extinction.

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But it was not only the dinosaurs who suffered from this event - over three quarters of the life forms on Earth became extinct; those species who survived were those that lived deep in the oceans or underground, and those who flourished as scavengers on the Earth's surface.

The actual cause of the extinction event has been the subject of scientific speculation for some years. Not all scientists agree that it was caused by an asteroid impacting the Earth. Other suggestions include the effects of massive volcanic eruptions, rapid climate change from warm and wet to cool and dry, and even the possibility that the dinosaurs became an evolutionary dead end and could no longer adapt to minor changes in their environment.

Until 1980, there was no strong consensus at all on what could have caused the extinction of the dinosaurs on a global scale, but a study of a clay layer in rocks from the period before and after the dinosaurs showed dinosaur fossils below the clay but none above. This was seen in rocks across the world, indicating a global extinction event, and the presence of iridium, a rare element on Earth but abundant in meteorites, in the clay layer gave an even stronger indication that the cause of this extinction was likely to be extra-terrestrial in origin.

In this demonstrator, students will put themselves in the position of a scientist, and study images of impact craters on Earth and try and simulate the types of impacts which caused these.

Their project includes two main tasks:

- 1) They will use Google Earth to find the position of known impact craters and measure their diameter.
- 2) They will then use the 'Impact Calculator' to investigate the type of objects which could have resulted in these impact craters on Earth.

Preparation

In order to prepare for the exercise, ask your students to familiarise themselves with Google Earth, ensuring they know how to enter coordinates and use the measuring tool (see attached pages: Measuring Impact Craters on Earth)

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Phase 3: Creation

Gather evidence from observation

Students can work in pairs on PCs. They will use Google Earth to find and measure the extent of the named impact craters and write their results in the spaces provided in the tables on the activity sheet.

Once the students have completed the first task details above, they will then go to the online impact calculator at:

http://education.down2earth.eu/impact_calculator

and follow the instructions given in the attached pages. Their results can be written in the tables given on the activity sheet.

Phase 4: Discussion

Explanation based on evidence / Consider other explanations

Ask students to answer the following questions in their pairs/teams.

1. How do your crater sizes compare with other's in the class? Why do you think there are differences?
2. Are all impact craters the same size?
3. What types of impactors create the largest craters? And the smallest?
4. What are the possible effects of impacts from space?
5. Can you see a relation between the size of an impact and its frequency?

Phase 5: Reflection

Communicate explanation

Make an overview of what has been discussed in the classroom during the exercise.

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Ask your students to present the results they obtained and produce a report with the information about the measurements and the results/conclusions. The students should try and comment on the accuracy of the method they followed and make suggestions for further work which they could carry out based around their observations.

Participating roles:

In this scenario students are introduced to impact craters on Earth and start by talking about impacts from space and what they know about them. After an introduction to the subject, they are acquainted with the Discover the Cosmos portal to learn how they can use Google Earth and the impact calculator. They then use Google Earth to measure the extent of given impact craters and attempt to simulate their production using the online 'Impact Calculator'.

The teacher is a facilitator. He/she introduces students to the relevant concepts, directs them to the task by asking questions and shows them how to use the tools. Then he/she allows them to perform their own measurements, and discusses the results with them.



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Tools, services and resources:

The scenario requires the use of:

1. Computers with internet connection, and both Google Earth and Flash player installed
2. Discover the COSMOS portal

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Measuring Impact Craters on Earth

In this activity you will be measuring craters of different sizes on Earth which are the result of an impact from space. The impacts causing these craters would result in a variety of climatic changes - small impacts would generally affect only the local area, whereas larger impacts could have massive changes in the global weather systems.




1. Finding and measuring impact craters

In order to find the impact craters that you will be measuring for this activity, you will have to enter the latitude and longitude of the craters into the 'Fly To' box in Google Earth. Once you have found a crater, you can save its position in so you don't have to enter its co-ordinates every time you want to view it.

- In the lat/long boxes, enter the co-ordinates of the place you wish to view. For example, to view the Barringer Meteor Crater click in the 'Fly to' box and enter 35 02 N, 111 01 W
- Google Earth will automatically fly across the Earth to the co-ordinates that you have sent it to. You can then add a placemark on your map by going to the main Google Earth menu at the top of the screen and clicking on **Add > Placemark**, or by clicking the  symbol at the top of the window.

A pin symbol in a yellow box will then appear on your map which you can move to the centre of your crater by dragging it with the mouse. Once positioned, you can enter its name in the pop-up box which has appeared, and this object will then be saved in your Google Earth folder under 'My Places'.

- To measure the craters listed in the table below, you will use the Measure tool in Google Earth. To find this in the main Google Earth menu, click on **Tools > Measure**. Or, click on the  symbol at the top of the window. A



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pop up box will appear in which 'line' is already selected. Click on the units box to select km.

You can now measure the diameter of each impact crater in Google Earth by using the left button of the mouse and dragging the line across the width of the crater.

The distance measured is shown in the pop-up box.

Measuring the sizes of impact craters

Find the following impact craters using Google Earth and measure their largest diameter (some of the craters are elliptical in shape, not round).

Crater Name	Latitude	Longitude	Size (km)
Barringer Meteor Crater	N3502	W11101	
This meteor crater was formed about 50,000 years ago by an iron meteorite impact. It is very easy to find in Google Earth.			
Manicouagan	N5123	W6842	
This impact crater is one of the oldest known craters on Earth. It was formed about 200 million years ago, and although some of the crater has been worn away by erosion, it is still very clear and easy to find in Google Earth.			



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CraterName	Latitude	Longitude	Size(km)
ClearwaterLakes	N5613	W7430	
<p>These 2 impact craters were formed by a pair of asteroids hitting the Earth's surface. In one of the craters, a circular area of islands can clearly be seen. This is an elevated part of the crater, as seen in a complex crater. The central part of the second crater cannot be seen however as it is below the water.</p>			
UpheavalDome	N3826	W10954	
<p>Originally thought to be a collapsed salt dome, this crater has all the features of a typical impact crater - a central peak, an inner crater and outer concentric shock rings. This makes it easy to identify in Google Earth.</p>			
GossesBluff	S2350	E13219	
<p>This impact crater in Australia is believed to have been formed over 140 million years ago. The central raised ring is not the rim of the crater - this lies much further out.</p>			
Tenoumer	N2255	W1024	
<p>This crater in Africa actually lines up with two other craters in the region. It is easy to identify in Google Earth - once located, try finding the larger crater to the south west.</p>			

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Comparing the sizes of impact craters with local distances

Once the size of each impact crater has been determined in Google Earth, a comparison can be made with distances local to your school or home. This will give some perspective on the sizes of these objects.

1. Enter the street name or postcode of your school/home in the '**Fly to**' box in Google Earth.
2. Once Google Earth has flown to your location, choose the measure tool once again by clicking on the ruler.
3. Using the mouse, left click on your location to mark the point where you would like your line to be drawn from. Make sure your units are in 'kilometres' again so you can make a proper comparison with the impact craters.
4. Zoom out of your location in Google Earth so that you can fit a line the size of one of the impact craters onto your map.
6. Finally, extend your line until its length equals the size determined for each impact crater previously. This puts into perspective how big the impact craters really are!



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Simulating impact craters

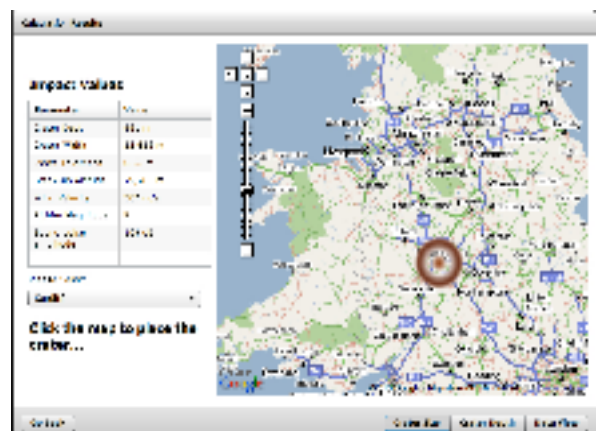
During this activity you will be simulating the effect of an impact on the Earth. You can change the physical character of both the impactor and type of ground that it hits and see what happens. The simulated results will be compared to existing Earth craters at various locations across the world.

Impact!

1. Go to the impact calculator at:

http://education.down2earth.eu/impact_calculator

- After selecting the language you want to use, click '**Start**'. You will be presented with a choice of 6 parameters you need to set before you can simulate an impact. These are:
 - the size (diameter) of the projectile
 - the composition of the projectile
 - the velocity of the projectile
 - the angle at which the projectile hits the Earth
 - the distance you are from the crash site
 - the composition of the target site.
- 3. Once you have chosen your parameters, click '**Submit**' and place your impact crater at various locations around the world.
- 4. Look at the effect of your impact by clicking on the '**Crater Depth**' and '**Data View**' buttons.



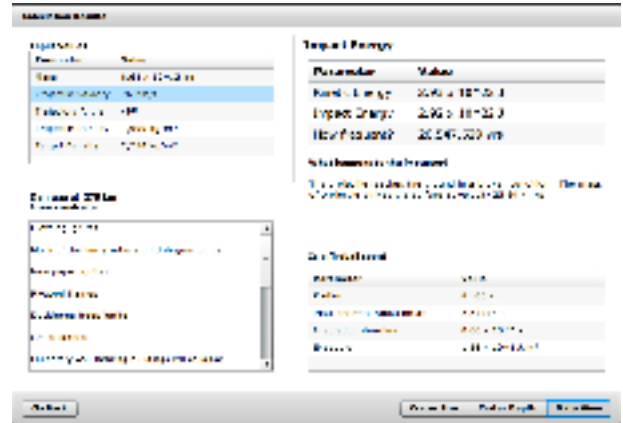
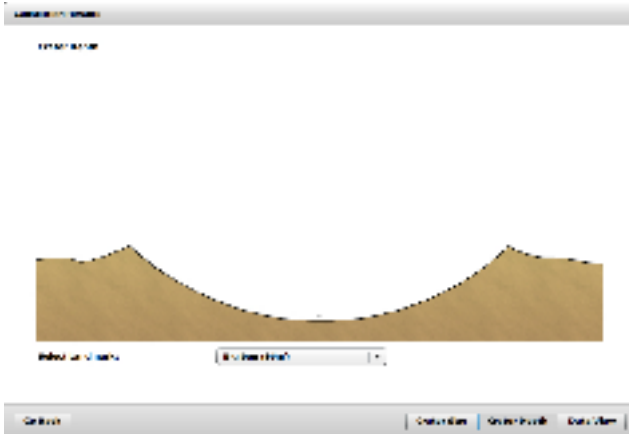
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Bang!

Now we are going to see if we can reproduce some of the real impact craters we see on Earth.

Use the data listed below to calculate the effects of each event. These values are estimates based on the real scientific investigations of these known impact craters on the Earth. Set your distance from impact as 500 km so that you are not destroyed by the larger impact events.



Barringer Meteor Crater, USA

Projectile Diameter: 100 m
 Projectile Density: Iron (8000 kg/m³)
 Impact Velocity: 20 km/s
 Impact Angle: 45°
 Target Density: Sedimentary rock



Ries Crater, Germany

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Projectile Diameter: 1500m

Projectile Density: denserock (2700kg/m³)

Impact Velocity: 20 km/s

Impact Angle: 30°

Target Density: Sedimentary rock

Chesapeake Bay, USA

Projectile Diameter: 3500m

Projectile Density: denserock (2700kg/m³)

Impact Velocity: 20 km/s

Impact Angle: 45°

Target Density: Sedimentary rock

Record your results in the table below:

Crater Name	Impact Energy	Crater Depth	Crater Diameter	Other effects	Frequency of impact
Barringer					

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Crater Name	Impact Energy	Crater Depth	Crater Diameter	Other effects	Frequency of impact
Ries					
Chesapeake Bay					

Snap!

Below are 3 impact craters found on the Earth. Using the impact calculator, can you fill in the gaps for the details of the impactor to match these craters? *Hint: There may be more than one way of forming each crater.*

Crater Name	Projectile Diameter	Angle of trajectory	Object Velocity	Projectile Density	Target Density	Crater Diameter
Tenoumer crater - Africa		45°	20km/s		Sedimentary rock	1.8 km

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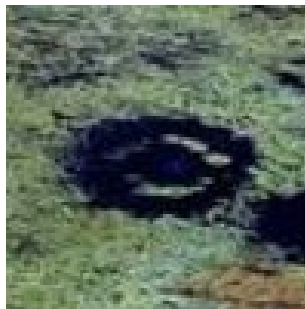
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Crater Name	Projectile Diameter	Angle of trajectory	Object Velocity	Projectile Density	Target Density	Crater Diameter
Clearwater Lakes-Canada		45°	20km/s			30km
Chicxulub-Mexico						110km

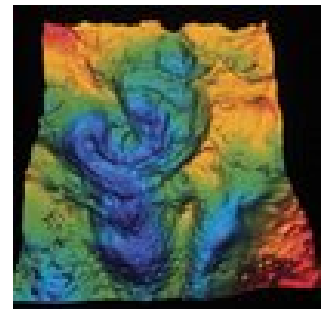
Tenoumer Crater - Africa



Clearwater Lakes - Canada



Chicxulub - Mexico



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