FRONTIERS

Bringing Nobel Prize Physics in the Classroom

FRONTIERS Demonstrators: The PEDAGOGICAL DESIGN

Dr. Margaret Farren, Dr. Yvonne Crotty, Joann Dempsey

Dublin City University (DCU)

FRONTIERS TEAM

DCU ELLINOGERMANIKI AGOGI NUCLIO EGO EUROPEAN GRAVITATIONAL OBSERVATORY IASA Paris Centre for Cosmological Physics

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Demonstrators - a series of innovative learning activities in the following physics research areas:

- non-accelerator physics,
- high-energy physics,
- detection of gravitational waves,
- cosmology,
- astronomy,
- optics and magnetism.

- different age groups.

FRONTIERS Project Website

VIEW THE DEMONSTRATOR

Exploring the Sun Does the Sun Rotate?

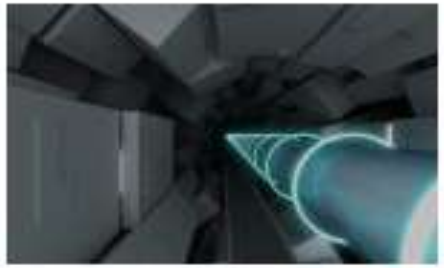
VIEW THE DEMONSTRATOR

Exploring the Sun: The differential rotation of the Sun

VIEW THE DEMONSTRATOR

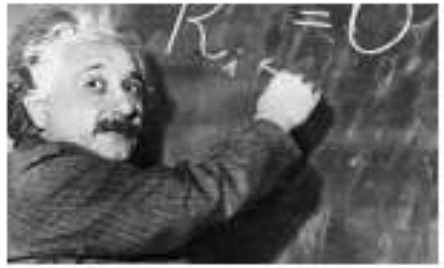
Discovering and building a Michelson interferometer

VIEW THE DEMONSTRATOR



How to accelerate particles

VIEW THE DEMONSTRATOR



Mass-Energy equivalence

VIEW THE DEMONSTRATOR

Relativistic Muons and Time Dilation

One page overview about the demonstrators can be accessed on the FRONTIERS website.

It includes key concepts, learning activities and key activities.

http://www.frontiers-project.eu/demonstrators/

(1). Stages of Inquiry

FRONTIERS Demonstrators on the Inspiring Science Education (ISE) portal follow an inquiry-based approach.

3 stage approach

- **Orientation**

  Orienting and Asking Questions

- **Exploration**
  - Hypothesis generation and Design
  - Planning and Investigation
  - Analysis and Interpretation
- **Consolidation**
  - Conclusion and Evaluation

Discovering Alien Worlds – The Discovery of an Exoplanet

Orienting & Asking Questions | Hypothesis Generation & Design | Planning & Investigation | Analysis & Interpretation | Conclusion & Evaluation

LISTEN CONTENT

Exoplanets

You certainly know that our planet orbits a star, the Sun, and that there are other planets revolving around the Sun in our Solar System.

The Sun is a small star formed 4.5 billion years ago from the gravitational collapse of a molecular cloud. The leftovers formed a disc-shaped cloud of gas and dust surrounding the Sun, out of which the planets and other smaller bodies of the solar system were formed. How they formed is still not clear and we find different theories to explain how it happened.

In this short video, Professor Stephen Hawking explains how the Earth and solar system were formed:

iSe Hi User! ASSESSMENT SETTINGS HELP

Discovering Alien Worlds – The Discovery of an Exoplanet

Orienting & Asking Questions | **Hypothesis Generation & Design** | Planning & Investigation | Analysis & Interpretation | Conclusion & Evaluation

LISTEN CONTENT

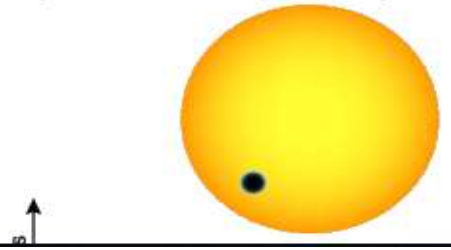
Let's think and generate hypotheses!

The image below represents a planetary transit and the light curve - the variation in brightness - of the star as the planet passes in front of the star.

With your colleagues, think about:

- why does the light curve have this shape?
- if there were no planet transiting, what shape do you think the light curve would have?
- how can scientists detect a transiting body?

Light Curve of a Star During Planetary Transit



Discovering Alien Worlds – The Discovery of an Exoplanet

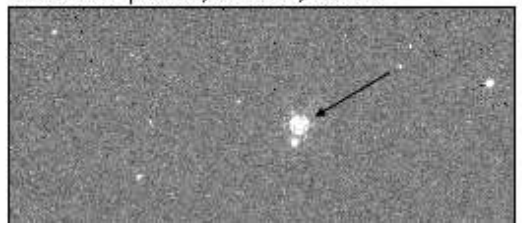
Orienting & Asking Questions | Hypothesis Generation & Design | Planning & Investigation | Analysis & Interpretation | Conclusion & Evaluation

LISTEN CONTENT

Plan investigation

Now that you understand planetary transits, let's study a real object. You will work with images taken with the NASA Spitzer Space Telescope. It is an infrared observatory launched to space in 2003.
The images will show you a region of the sky with lots of stars. There are 3 brighter stars in the field for which you will gather data. Out of those 3 stars, you will gather evidence to identify one of them that might have a transiting body. Remember that the planet is not visible - you have to build light curves and analyse them to look for characteristics of the light curve of a star with a transiting planet.

256x256 pixels; 32-bit; 256K



Discovering Alien Worlds – The Discovery of an Exoplanet

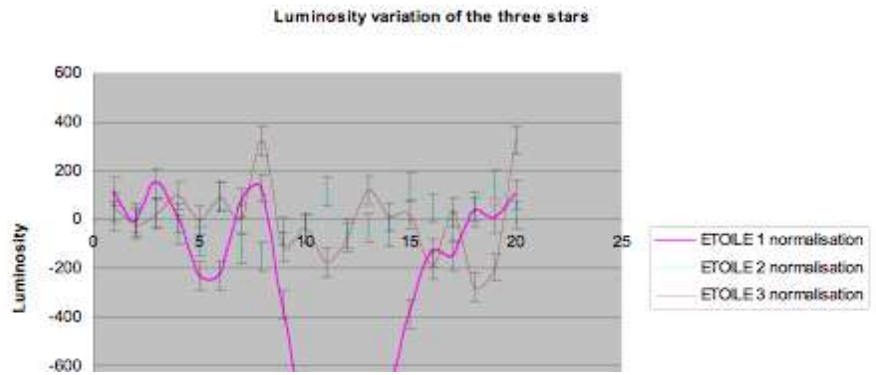
Orienting & Asking Questions | Hypothesis Generation & Design | Planning & Investigation | **Analysis & Interpretation** | Conclusion & Evaluation

LISTEN CONTENT

Analysis and Interpretation: Gather result from data

Finished doing the photometry? Look at the light curves of the 3 stars.

You should have a result similar to this one:



Discovering Alien Worlds – The Discovery of an Exoplanet

Orienting & Asking Questions | Hypothesis Generation & Design | Planning & Investigation | Analysis & Interpretation | Conclusion & Evaluation

LISTEN CONTENT

Conclude and communicate result/explanation

Explanation: Formulate an explanation based on the analysis of your evidence

From the discussion with your colleagues, write about your findings:

- Do you think you detected a transiting body?
- Is it feasible that it is a planet?
- What other kind of object could it be?
-

Connect explanation with current scientific knowledge

As you know, this exoplanet has already been studied by astrophysicists. You can find the most reliable scientific data on The Extrasolar Planets Encyclopaedia (http://exoplanet.eu/).

(1). Stages of Inquiry

Orientation phase

- Orientation provokes curiosity (orientating and asking questions) by providing prior knowledge or information that is necessary to the students' inquiry process.

Exploratory phase

- Students investigate a scientifically oriented question or statement.
- Evidence: Student gives priority to evidence.
- Analyse: Students analyse evidence
- Explain: Students formulates explanation based on evidence.

Consolidation phase

- Connecting information with current scientific thinking,
- Reflecting on the learning process
- Communicating and justifying the explanation.

(1). Types of Inquiry

Structured Inquiry	Guided Inquiry	Open Inquiry
• Strongly teacher directed • Students follow teacher's direction in pursuing an investigation or to produce a prescribed product.	• More loosely scaffolded (supported). • Students take more responsibility for establishing the direction and methods of their inquiry.	• Students take the lead in establishing the inquiry questions or investigation methods.

Less — Student self-direction — More

More — Direction from the Teacher — Less

This video is designed to guide you through the inquiry based approach with the use of an example question

'Do Sports Drinks Work?'

(2). TPACK

- TPACK framework with focus on the following:

Technology / tools embedded in the demonstrator and/or supporting it.

Pedagogical knowledge – The teachers' knowledge of the practices, processes, and methods regarding teaching and learning.
Types of Inquiry and Process of Inquiry.

Content knowledge – Topic (area of physics). Learning Outcomes.

Punya Mishra and Matthew J. Koehler's 2006 TPACK framework

Content Knowledge - Learning Outcomes

Example Demonstrator: Discovering Alien Worlds - The discovery of an exoplanet

- Cognitive Statements deals with knowledge, concepts and understanding.
  - Will the demonstrator help the student develop knowledge of a topic?
- Affective statements include feeling, interest, attitudes, an appreciation that may result from science instruction.
  - Will the demonstrator motivate the student in this topic? Will it help to change their attitude?
- Psychomotor Statements includes outcomes that emphasis physical skills.
  - Will the student use software e.g. image analysis software? Will they construct something?

Content Knowledge - 21st Century Skills

21st century skills refers to a set of abilities that students will require if they are to succeed in today's workplace and society.

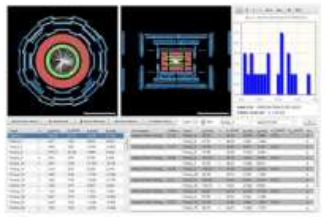
- 1. Learning and innovation skills:
  - Communications and collaboration.
  - Creativity and critical thinking.

- 2. Digital literacy skills: information literacy, ICT literacy.

- 3. Life skills:
  - Responsibility – collect and analyse data.
  - Flexibility – changing plans to accommodate feedback.
  - Initiative – plan use of resources, manage time.

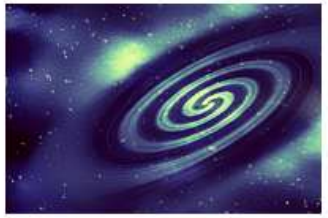
Technology / Tools

- Demonstrators are embedded in a technology-enhanced learning environment.
- Technology used in the various stages of the inquiry process.



Search for the Z and Higgs bosons

VIEW THE DEMONSTRATOR



Gravitational Wave Noise Hunting

VIEW THE DEMONSTRATOR

Finding black-holes in a chirp

VIEW THE DEMONSTRATOR

Measuring the recess velocity of distant galaxies

Black Holes in my Classroom

Build your own Cloud Chamber

FRONTIERS Lesson Plan Template
Working group

- The lesson plan template has been designed to help you create your own lesson plan for a class.
- You will be introduced to the lesson plan template during the working group session.
- A video about the template has already been emailed to you.

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Thank You