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REPOSITORY OF INSPIRING SCIENCE EDUCATION PROJECT ABOUT SPACE AND ASTRONOMY IN SCIENCE EDUCATION

Panagiota Argyri, Evangeliki Model School of Smyrna, Greece

Abstract

Astronomy is one of the most exciting and rapidly evolving branches of science. Astronomy has influenced our history and culture through its practical applications and its philosophical and religious implications. Historically, not only scientists and students, but generally people are widely interested in the achievements and advances of space science. Space Science research seeks to increase our understanding of the solar system and the universe. In order to support teaching astronomy and space in science education, we present a brief description of ways in which classroom teachers can use the repository of the Inspiring Science Education project (ISE) to enhance space education and develop students' scientific inquiry skills in astronomy observations.

Introduction to the Inspiring Science Education portal

The Inspiring Science Education (ISE) portal (http://www.inspiringscience.eu) provides digital resources and opportunities for teachers to help them make science education more attractive and relevant to students' lives. Through the Inspiring Science Education website and the activities organised by the partners, teachers can help students make their own scientific discoveries, witness and understand natural and scientific phenomena and access the latest, interactive tools and digital resources from within their classrooms.

Key outcomes of the Inspiring Science Education project:

- Access to online, interactive tools and digital resources from all over the world that can be used for science teaching.
- Templates, scenarios and methodologies to support science teachers and teacher trainers in their effort to make their teaching more exciting, fun and relevant to students.
- A platform that can be used by students and teachers alike to take science teaching beyond the classroom and into the realms of extra-curricular learning
- A variety of eTools and digital resources that provide opportunities for students to collaborate with each other (in or out of the classroom) or with others outside of the class.
- Inspiring Science Education is all about providing the tools to make science education.

ISE is providing digital tools for space and astronomy in science education:

- Students are engaged in science education if they are "actively constructing knowledge from a combination of experience, interpretation and structured interactions with peers and teachers" (Roschelle et al., 2000; p.79), so they are more likely to gain an expert understanding of science concepts. Digital tools are one way to expose children to this type of learning. Indeed, as researchers have begun to understand more about the situations in which students learn best, they have found that "the structure and resources of traditional classrooms" are often inadequate and that "technology – when used effectively – can enable ways of teaching that are much better matched to how children learn" (Roschelle et al., 2000; p.79).
- Scientists routinely use a number of digital and technological tools in their daily practice, including virtual laboratories and simulations, models of scientific phenomena. While students are unlikely to have access to many of these tools in the classroom, they can use similar digital tools to work like scientists; by collaborating with their peers, modelling scientific processes, conducting virtual experiments, and actively participating in research with scientists locally and around the world. There are many choices in the repository of digital tools of the ISE for astronomy and space science education. STEM teachers could select what fits best the topic of astronomy, objects related to space, expected results, their students, their classroom, their curriculum, and their teaching style.
- Virtual Observatory Labs.

Robotic telescopes give STEM teachers access to astronomy data that they could include in many inquiry-based activities in many subjects (physics, chemistry, mathematics, environmental studies). The Las Cumbres Observatory Global Telescope as an education partner of the Global Telescope Network (LCOGTN) (http://portal.opendiscoveryspace.eu/content/las-cumbres-observatory-global-telescope-673563) demonstrates how a very complex scientific instrument works. The basic aim is to offer a fully supported education programme to encourage teachers and students to engage in research-based science education. Directions of how to use them as part of inquiry lesson plans are fully supported by a range of educational materials and a team of educators and professional astronomers. (http://www.faulkes-telescope.com/resources/videos/ft-lcogt_introduction). Also, in Education and Outreach links there are many recourses and examples that teachers could use in their classroom: http://lcogt.net/spacebook/, http://lcogt.net/opensource/, http://lcogt.net/observations/, http://lcogt.net/images/space/.

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Additional supportive material of LCOGTN

Agent Exoplanet is a virtual lab of LCOGTN that includes the ISE repository digital tools

(http://portal.opendiscoveryspace.eu/content/agent-exoplanet-677762)

Extra-solar planets (exoplanets) are an exciting branch of astronomy which has exploded in the last decade, with almost 1000 known exoplanets discovered in the Milky Way. This exploration is a triumph of human curiosity akin to exploring the world from out of caves. Agent Exoplanet is an interactive online resource in which you become the investigative astronomer. Using data from real telescopes from the Las Cumbres Observatory network, you can analyse planets which orbit stars other than our Sun. Using Agent Exoplanet, you will study already discovered exoplanets applying the exact same methods as astronomers to measure the changes in the brightness of a star whilst a planet moves in front or behind it. You can examine as many images as you like, making critical measurements which will reveal the size of the planet and how long it takes to go around its star.

Star in a Box is an analysis tool of LCOGTN that includes the ISE repository digital tools

(http://portal.opendiscoveryspace.eu/content/star-box-677868)

It involves an interactive Hertszprung Russell diagram which is included in the curriculum for UK Schools at GCSE, A level and also at undergraduate level. Siab is an interactive Hertszprung Russell diagram which plots brightness of stars against their temperature to show the different types of stars and their lifecycle from star formation to star death (this is based on a real published stellar evolution model). It allows the user to interact via looking at different information and reading values of stellar mass, temperature, age etc., as well as fundamentally seeing that the properties of their "model" star change as it ages. Students can plot their own graph and learn names of the stages of stars, e.g. main sequence, red giant etc.

Interactive tools from ESA Science missions

(http://portal.opendiscoveryspace.eu/content/science-esa-vodcasts-688290)

ESA Science Educational Support web pages offer an overview of educational material that has been prepared with the support of the ESA Science and Robotic Exploration Directorate (http://sci.esa.int/education/35001-interactive/). Telescopes for using in inquiry lesson plans on atmospheric effects or power of celestial bodies, animation with space travels, 3D models of galaxy, illustrations of observations in stars, simulations for searching planets, movies on the Formation of Planets and Asteroid Belt. To inform primary school pupils about space, ESA includes news, background information, animations, games and hands-on activities related to space. (http://portal.opendiscoveryspace.eu/content/esa-kids-677028). Also, on the website of ESA (http://www.esa.int/Education) there are many relative links with activities (Hands-on projects, Support to teachers, International cooperation activities, Opportunities for students, Outreach initiatives) that provide innovation approaches in space education.

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Virtual Reality tools

Celestia (http://portal.opendiscoveryspace.eu/content/celestia-676927) is an open-source free space simulation that explains the scientific process and lets you explore our universe in three dimensions. It has a large community of people producing resources using Celestia as a base and there is a repository of resources, educational and other, on: http://www.celestiamotherlode.net/.

Chromoscope (http://portal.opendiscoveryspace.eu/content/chromoscope-676928) for exploring the whole sky at a range of wavelengths on the website http://www.chromoscope.net/. It allows the user to view the sky at a range of wavelengths.

Dark Skies Rangers (http://portal.opendiscoveryspace.eu/content/dark-skies-rangers-677011) is a virtual reality tool cited in http://www.globeatnight.org/finding and demonstrates how scientists work and it helps explain the scientific process. Its goal is to raise the level of public knowledge about adverse impacts of excessive artificial lighting on local environments and help more people appreciate the ongoing loss of a dark night sky for much of the world's population. Toward this end, a range of programs and resource material have been developed.

Virtual labs

3D Games Based Go Lab Simulations (http://portal.opendiscoveryspace.eu/content/3d-games-based-go-lab-simulations-688294) support students in manipulating, testing, exploring, predicting, questioning, observing, analyzing and making sense of the natural and physical world. Labs will immerse students in rich 3D immersive environments where they will experience branching and unfolding learning journeys based on enquiry/investigation of various science topics such as Nature of Light, Environment and Climate Change, Electromagnetism, Energy/Renewable Energy, Geography and Geology, Health, Rain Forest, Mechanics.

Eyes on the Solar System 3D (http://portal.opendiscoveryspace.eu/content/eyes-solar-system-3d-677832) is a space simulation that lets you explore our universe in three dimensions. It has 3 major components: Eyes on Earth, Eyes on the Solar System and Eyes on Exoplanets.

Design a Space Telescope (http://portal.opendiscoveryspace.eu/content/design-space-telescope-831233) is a

Virtual lab that helps students explore the kinds of decisions the astronomers and engineers have to make as students design their own space telescope (http://chrisnorth.github.io/design-a-space-telescope/#).

Community of innovative practices

Community of Discover of Cosmos (http://portal.opendiscoveryspace.eu/community/discover-cosmos-70530) in the ISE portal brings together teachers who are using resources, virtual experiments and online labs from the fields of Astronomy. Also, STEM teachers could find digital tools

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(http://portal.discoverthecosmos.eu/repository/tutorials/astro) for the analysis of astronomical images, classification of elliptical galaxies, globular clusters and their ages, open clusters, estimating the mass and star formation rate in galaxies.

Digital Educational recourses

The portal of the Inspiring Science Education (ISE) project has developed the technical infrastructure for designing and delivering technology-enhanced interdisciplinary lessons following Inquiry Based Science Learning (IBSL) (Zervas & Sampson, 2015). Educational scenarios or lesson plans include a widely used inquiry learning model is the 5E Model, which lists five inquiry phases: Orienting & Asking Questions, Hypothesis Generation and Design, Planning and Investigation, Analysis and Interpretation, Conclusion and Evaluation (Zervas & Sampson, 2015). Each phase of the inquiry cycle includes a set of inquiry activities.

- Digital educational resources of any type (text, images, videos).
- External digital educational resources stored in the ISE Portal.
- External digital educational tools stored in the ISE Tools Repository.
- Guidelines/notes for the teacher to implement the inquiry activity.
- Assessment tasks to assess students' knowledge and provide feedback.
- Teachers should be able to add at the end of each inquiry phase appropriately (Zervas & Sampson, 2015).

Problem solving as a key component of IBSL

Chang and Weng (2002) suggest that a significant correlation exists between students' problem-solving ability and the science process skills in Earth and space sciences. The research indicates that learning increased measurably when students were educated in solving problems and then placed in situations requiring them to seek information, reflect on observations, and apply knowledge to new scenarios (Chiappetta, 1981). Thus, in each phase of the lesson plans ISE platform, there are two questions of PS in order to support teachers to be able to measure (among others) the effectiveness of IBSL.

Inquiry Based Learning Lesson Plans demonstrations

The Big Bang

In this lesson, students will learn the three main lines of evidence for the Big Bang: the universe is expanding, the Cosmic Microwave Radiation, and the mixture of chemical elements.

(http://portal.opendiscoveryspace.eu/edu-object/big-bang-836583)

Life cycle of Stars

Exploration of the lifecycle of stars, using an interactive web-app showing animations of how stars change over the course of their lives. (http://portal.opendiscoveryspace.eu/edu-object/star-box-scenario-test-demo-835896)

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Age of the Universe

Investigation of the age of the Universe by observating galaxies, finding their distances and their velocities, and finding that they are all moving away from us.

Is the Moon really larger when you see it on the horizon?

This Astronomy activity (Is the Moon really larger when you see it on the horizon?) on the UniSchooLabs repository was originally developed at the Harvard-Smithsonian Center for Astrophysics in the MicroObservatory project. It includes an opening challenge (described below) that sets up the context for students. Opening challenge:

> *"You're sitting on a beach, watching the Moon rise. It looks big — really big. A few hours later, when it's high in the sky, it looks a lot smaller. What's going on? You know the Moon itself hasn't shrunk. But is the image of the Moon on the horizon actually bigger? Or is your brain playing tricks on you? Your challenge is to design and carry out an experiment, using a remote telescope and its camera, to answer the question, 'Is the Moon really larger when it is near the horizon than when it is higher in the sky?" http://portal.opendiscoveryspace.eu/edu-object/moon-really-larger-when-you-see-it-horizon-838971*

Stars and Energy Transport

In this lesson, students investigate the primary ways in which energy is transported: convection, conduction, and radiation. (http://portal.opendiscoveryspace.eu/edu-object/stars-and-energy-transport-834772)

Building Constellations

This activity helps students identify a few constellations, realize what constellations are (areas in the sky) and their important role in the history of the mankind. Using the planetarium software Stellarium and Digital Universe, students will discover that stars on the same constellations are unrelated to each other and with a hands-on model they will understand why stars seem to be all at the same distance. (http://portal.opendiscoveryspace.eu/node/838964)

Following Curiosity Mars

The students will follow the rover Curiosity on its way to the red planet Mars by using the World Wide Telescope. The didactical approach is based on scientific inquiry in order to give students the enjoyment of finding out for themselves and initiates appreciation of the nature of scientific activity, of the power and the limitations of science. The main question will be: Where is Curiosity now? The educational activity will benefit from e-learning tools like WWT, and some web resources. Because students will have to solve a real problem of the humankind, they will have to accompany the rover Curiosity on Mars. The final product of

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the teams of students will be the presentation of the slide show (http://portal.opendiscoveryspace.eu/edu-object/following-curiosity-mars-837512).

Finding new a human house in outer space

The inquiry based approach consists of finding the real problems of living on this beautiful planet, Mother Earth, in order to start searching another house for humans on another planet from the Solar System. They will also use the World Wide Telescope for exploring the planets of the solar system and for building the slide show. Which planet of the Solar System is the most similar to Earth in order to send there a space colony? At least for the beginning, we will remain in the Solar System, but it is possible to go further one day. Present your ideas regarding the way to gain a new house for humans abroad Earth. What planet will you choose from the Solar System? http://portal.opendiscoveryspace.eu/edu-object/finding-new-house-humans-outer-space-838963

The Multiwavelength Universe

An introduction on the investigation of the electromagnetic spectrum from the point of view of astronomy. http://portal.opendiscoveryspace.eu/edu-object/multiwavelength-universe-836589

Gas Laws with Stars and Nebulae

In this Hangout, we will consider the gas laws and look at different kinds of nebulae. (http://portal.opendiscoveryspace.eu/edu-object/gas-laws-stars-and-nebulae-838970)

Digging into Comets

In this lesson, students investigate comets and explore how they brought water to worlds like Earth. (http://portal.opendiscoveryspace.eu/edu-object/digging-comets-838969)

Conclusion

The ISE portal supports many kinds of activities for learning and teaching astronomy and brings the scientific method in classroom. Astronomers understand the universe by comparing its observed appearance with the predictions of theories or models; they cannot understand stellar life cycles, for instance, by breeding star. As students study the methods of astronomers, they get familiar with an experimental and observational model in science that provides the scientific investigation (Percy, 2006). Astronomy is included in many interdisciplinary subjects in science for example, many concepts of physics (gravitation and relativity, light and spectra).

On the other hand, Space Science research seeks to increase our understanding of the solar system and universe. Four major themes in Space Science are: Astronomical Search for Origins, Structure and Evolution of the Universe, Solar System Exploration, and the Sun-Earth connection. Studying stars and planets we learn about the Sun and our own planet, the Earth. It also helps us to learn how stars, planets, and galaxies evolved and how the universe

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was formed. While students learn about the exploration of space and study astronomy, they deal with big ideas of Science:

- There are four fundamental interactions/forces in nature: Gravitation, electromagnetism, strong nuclear, and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
- The Earth is a very small part of the Universe: The universe is comprised of billions of galaxies, each of which contains billions of stars (suns) and other celestial objects. The Earth is a very small part of a solar system with our sun in its centre that in its turn is a very small part of the universe.

Big Ideas of Science are a set of cross-cutting scientific concepts that describe the world around us. They allow us to conceive the connection between different natural phenomena that at a first glance may look irrelevant but in fact have their roots in the same principles and laws of nature.

The Earth and Space Sciences education is undergoing a remarkable transformation. Long perceived as a 'minor' science (in contrast to physics, chemistry and biology), the Earth and Space Sciences are emerging in both public perception and active science research as a profoundly important field. Our lives and future depend on the depth of our understanding of our home planet. The concept of the Earth as a rich and complex system of interconnected components and processes has become a dominant paradigm in science. Furthermore, the Space Age has provided a revolutionary new perspective on the Earth, enabling us to see, explore and investigate our world in ways never possible before (National Conference on the Revolution in Earth and Space Science Education).

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