Lesson 1
Our Views about the Cosmos

Teaching Scenario

MAIN IDEA

Already since Antiquity humans sought to interpret and predict the celestial phenomena, a process that gradually led to the creation of descriptive models about the structure of the Cosmos. The geocentric model that predominated during the ancient era and up to the Middle Ages, was for centuries the main pillar for the interpretation of the astronomical observations. The shift to the heliocentric view constituted a decisive step towards the modern understanding of the movement of celestial bodies

GENERAL AIM OF THE TEACHING SCENARIO

The aim of the teaching scenario is the description by the students of the two main cosmological models and the understanding of the evolving nature of scientific theories. Finally, students will have the chance to get an insight into the opportunities that the study of Science can open to them in the labour market.

SCIENTIFIC CONTENT

The geocentric and the heliocentric models were used in order to interpret the universe and the motion of the celestial bodies. According to the geocentric model the Earth was placed at the center of the universe, whereas according to the heliocentric model the Sun was placed at the center of the universe. Both models gave satisfactory interpretations of the celestial motions and this is why we study them even in our times.

The most prominent proponents of the geocentric model were Aristotle (4th century B.C) and Ptolemy (2nd century A.D). This is the reason why the geocentric model is also known as the “Ptolemaic system”. The most prominent proponents of the heliocentric system were Aristarchus (3d century B.C), Copernicus (15th–16th century) and Kepler (16th-17th century). This is why the heliocentric model is also known as the “Copernican system”.

The telescope, as an astronomical instrument, according to the modern sense of the term, was used by Galileo (who also confirmed that the Earth is not at the center of the Universe).

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STUDENT IDEAS (misconceptions)

- Scientific theories remain unaltered (Agan & Sneider, Egger, 2009a)
- Many students believe that the sun is moving whilst the Earth remains motionless (Jones et al., 1987; Vosniadou & Brewer, 1990; Baxter, 1989; Kalkan & Kiroglu, 2007; Trumper, 2000; 2001; 2006a; 2006b)

A) INSTRUCTIONAL OBJECTIVES

Knowledge:

The students, after the end of the lesson, shall be able to:

- Describe the main cosmological models.
- Distinguish the differences between the main cosmological models.
- Understand the evolving character of scientific theories.

Skills:

The students, after the end of the lesson, should be able to:

- Classify the planets of the Solar system
- Understand the process of construction and the principles of function of a telescope

Attitudes:

After the completion of the lesson, the students shall be able to:

- Cooperate in groups.
- Develop a positive view about Science.
- Develop a positive view of the STEM related professions.

B) TEACHING MEANS AND MATERIALS

- Video projector
- PC
- Internet connection
- Storytelling Video
- Digital simulations
- Presentation with presentation software
- Materials for the construction of a simple telescope
- Materials for the various hands-on activities
- Worksheet for the student
- Evaluation sheet for the student

C) TEACHING METHODOLOGY

We suggest the specific teaching proposal (Inquiry-based learning) based on the following theoretical assumptions:

A. The new knowledge is constructed by the student and is not transmitted by the

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teacher. The already existing knowledge plays a significant role for the learning of the students. Based on the social dimension of knowledge, learning is conducted through social interaction.

B. The teaching is structured from the specific to the abstract, or from the partial to the general.

C. The use of analogies in teaching connects the already existing knowledge of the student with the new knowledge.

D. The cooperation between the students in small groups facilitates their social interaction and their learning, especially in what concerns difficult cognitive goals.

E. The teaching of aims relevant to science is preferably to be conducted in a direct manner, where each stage of the scientific methodology is presented and evaluated distinctly.

As it has been pointed out (Egger, 2009a, Egger 2009b), the teaching about the scientific procedures can be based on the following ideas:

a. To make the scientific procedures explicit instead of implicit to the students.

b. To use storytelling.

c. To use real data

In the present teaching scenario, the scientific procedures are explicit. In our teaching approach we use simulations and images and also real data. Also, activities of constructivist teaching are included, such as the promotion of the ideas of the students by asserting their own hypotheses, and the meta-cognitive activity of the comparison between the hypotheses and the conclusions of the students. The teaching scenario also includes an activity which aims to connect the object of astronomy, and more general, science and engineering, with the labour market.

F. The instructional procedure followed is in accordance with the inquiry-based learning method that includes the following steps:

- The phenomena
- Questions by the students
- Questions of the lesson
- Answers/Hypotheses
- Experimentation (data from simulations and images)
- Conclusion
- Comparison between the initial hypotheses and the final conclusions of the students.
- Generalization
- Extension/Application.

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Open-Structured Inquiry

The inquiry-based method of learning-teaching may be determined either as a non-structured or open inquiry, or as a structured inquiry. The subject (teacher or student), who determines the procedure and the activities, also determines the type of the inquiry method. According to the open inquiry method the student is the one who determines the phenomena of study, the questions, the procedure, the conclusions. According to the structured inquiry the teacher is the one who determines the majority of the teaching variables, whilst the students participate in the procedure and reach conclusions, which are then used in order to answer the questions (Bunterm et al., 2014).

The proposed method of teaching is a combination of open inquiry and structured inquiry. The activities up to the point of the questions posed by the students are the beginning of an open inquiry procedure, while the rest of the teaching course follows the lines of structured inquiry.

D) CONSTRUCTION OF THE EVALUATION TEST

The evaluation test was constructed on the basis of the following principles:

- The questions correspond to the instructional objectives.
- Questions of various types were used (of objective and open type) (Kassotakis, 2010)
- In the questions about attitudes the students answer with a "Yes" or a "No"[1].

E) LESSON DURATION

Two teaching hours, 90 minutes.

F) STAGES OF THE TEACHING APPROACH

Introduction -Framework of the lesson (2 minutes)

The students are distributed to groups of 4-5 persons. The aims and the course of the lesson are presented by the teacher.

Activity 1: Storytelling with video (7 minutes)

The class is divided into work groups of 4-5 students. The worksheet is handed to each group. The video with the storytelling is presented, in order to induce questions to the students. After the storytelling images about the two basic models of the solar system are projected.

[1] The analysis of the attitudes can be performed by the classical theory of responses (Türk, 2015), or by the modern corresponding theory (Tang, 2016).
The teachers can find many similar questions in the paper of Chapman, Catala, Mauduit, Govender και Louw-Potgieter (2015) "Monitoring and evaluating astronomy outreach programmes".

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Storytelling

"First Chaos was made

And after a while, the broad Earth

And the beautiful Eros.

From Chaos, black Night and Erebos were born

And Night gave birth to Ether and Day

Broad Earth, then, gave birth to the starry Sky

Equal to herself, to cover her all around

Then, she gave birth to the abysmal Sea

The Mountains,

The deep Ocean…"

Thus describes Hesiod the begin of Cosmos. Some said, that Night gave birth to an egg, and from which Eros emerged, who matched all the forces of the world ·and made possible the birth of the Sky and the Earth, the Ocean and of other gods.

And the Day, the Earth, the Ocean were born.

But, man never stopped wondering about the Cosmos surrounding his Earth, about the Cosmos surrounding him. Various theories were being developed, until, philosopher Aristotle appeared in Greece. He spoke about the Universe, and put Earth at its center, staying motionless, while around her, on their spheres, the Sun, the Moon, the stars were revolving… Always having as their center the Earth. For many years men believed that their Earth, and they themselves, were the center of the Universe. And this belief did not change either with the theories of the Pythagoreans, who put at the center of the Universe a celestial sphere made out of fire, nor the theories of Aristarchus who claimed that the center of the Universe was the Sun.

Time passed, up to the moment that Copernicus appeared. His great passion was the study of Greek philosophers. He studied them all and found that somewhere there, some said that the Earth, moves… Then, he built a tower, stayed out on its huge balcony every

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night with his astronomical instruments. He measured the angles between the heavenly bodies and the line of the horizon, measured the phases of the Moon, the succession of the seasons. He observed, he investigated, he formulated his investigation and recorded them until he reached a conclusion, that shocked even himself. The Earth was not the center of the Universe, and the Universe was much larger than it was believed to be until then. He expounded all of his observations, all of his conclusions in a book entitled *"On the Revolutions of the Heavenly Spheres"*. But when it was released, it shocked the then conservative society. They called him crazy, they said that he wanted to overturn the art of astronomy; they called him a blasphemer, his ideas were persecuted... But, the river could not turn back. The age of the New Science had just begun.

Years later, Galileo appears. He is passionate about the study of the skies. He builds a telescope, and turns it to the vault of heaven. He looks greedily at the planets, he looks at the Sun, his dark spots, he looks at the surface of the Moon. A whole new world opens up before his eyes. He understands that the Moon, the Moon for which the poets have written their most beautiful poems, was just a piece of matter, just like the Earth... our Earth. He realised then, that the stars and the Moon, comprise Nature. Galileo proves that the Earth is not the center of the Universe. He inspires many scientists· one of them is Kepler, who formulated his laws about the motion of the heavenly bodies.

When Galileo dies, Newton is born. He also has a passion with the study of heaven. He is inspired by Galileo, by his description of Nature. One day, when he is twenty three years old, looks at an apple tree. He sees an apple falling and landing, where else? On the ground... At this moment, in Newton's imagination, the Moon became the apple which is also attracted by Earth in the same way...He studies, he investigates, he observes, he formulates the laws of gravitational attraction... And, he speaks about the Universe, as if it were a huge machine with strict determinism.

Nowadays, with physics and mathematics, with the telescopes and the instruments we have, we can speak, we can speculate about the first moments, during which, as suggested, the Universe was born. To speak about the great explosion, the Big Bang...

Activity 2: Questions of the students (2 minutes)

The students are guided to formulate their questions based on the storytelling and the images and write down their questions on the worksheet.

Activity 3: Questions of the teacher (2 minutes)

1. Which are the main views about the solar system and the Cosmos since Antiquity and up to the present day?

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2. Which are the differences between these views?
3. Do scientific theories change, or do they remain unaltered?
4. Which are the planets of our Solar System?
5. How is a telescope constructed? How does it function?

Activity 4: Answers-Hypotheses of the students (5 minutes)

The students write down their answers to the above questions on the worksheet, without any help from the teacher.

Activity 5: Investigation of the 1st question. (3 minutes)

A simulation of the motion of the planets according to the geocentric model is presented. The students are asked to write down on their worksheet the basic characteristics of the geocentric model. The teacher may present the simulation using the relevant link or by downloading and executing the relevant file from the platform (recommended).

Activity 6: Investigation of the 1st question (3 minutes)

A simulation of the motion of the planets according to the heliocentric view is presented. Based on the presented material the students write down on the worksheet the characteristics of the heliocentric model. The teacher may present the simulation using the relevant link or by downloading and executing the relevant file from the platform (recommended).

The teacher also presents the simulation that simultaneously demonstrates the two models.

Activity 7: Investigation of the 2nd question (3 minutes)

The students, based on their previous answers and on the simulations, are asked to write on the worksheet two differences between the two cosmological views.

Activity 8: Investigation of the 3rd question (3 minutes)

The students answer on the worksheet the question about the changing nature of scientific theories and justify their answers.

Activity 9: Investigation of the 4th question (20 minutes)

In this activity students are asked to classify the planets of the solar system on the basis of their distance from the Sun by using simple materials (soda cups). They will be making use of the information on the cards distributed to them, about main characteristics of each planet (distance from the sun, mass, volume, number of satellites). It is

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recommended that the teacher distributes the cards in a random order to the groups so that students can make comparisons.

Activity 10: Investigation of the 5th question (12 minutes)

The teacher demonstrates the construction of a simple telescope, made by simple materials. The function of the telescope is discussed in the classroom[2]. Every group of students gets its own telescope.

Activity 11: Comparison between the final results and the initial answers of the students (5 minutes)

The groups of the students compare their initial answers with the final conclusions.

Activity 12: Application of the conclusions (2 minutes)

The teacher projects a simulation and the students answer to questions about the application of the conclusions.

Activity 13: Connection of the lesson with the labour market (10 minutes)

In the specific activity students are asked to suggest solutions to a problem related to the practice of STEM specialties. Every group presents its suggestions to the classroom[3].

Activity 14: Evaluation Sheet (5 minutes)

The Evaluation Sheet is handed out and filled in.

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[2] The teacher can find the instructions about the construction of the telescope in the appendix of the demonstration file.

[3] STEM specialties: e.g. physicist, chemist, engineer, biologist, mathematician et cet.

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