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SCIENTIFIC-PEDAGOGICAL ANALYSIS OF TEACHING THE SOLAR SYSTEM IN NATURAL SCIENCES TO ELEMENTARY STUDENTS

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Abstract.
This article systematically analyzes the scientific and pedagogical approaches used in teaching elementary school students the structure of the universe, the classification of planets, and the geological features of the Earth. Based on textbook materials, methods are described for developing students' spatial imagination and explaining complex natural processes to them in a simple and logical way. The article substantiates the effectiveness of methods such as historical-comparative analysis, problem questions, visual modeling, and observation.

Keywords. Solar system, Sun, Mercury, Venus, Earth, Moon, Mars, Jupiter, Saturn, Uranus, Neptune, gas giants, natural satellites, atmosphere, space exploration, physical properties of planets, orbital motion, ring systems, astronomical observations

The first step in forming a correct scientific worldview in students about the universe is to work with their existing knowledge. In many cases, children have incorrect ideas about the universe that they have received from fairy tales, cartoons, or legendary sources. Therefore, it is appropriate to start the lesson with a historical-comparative analysis. The illustrations in textbooks that reflect the ideas of ancient people about the universe (for example, the Earth in the form of a plane standing on a turtle and elephants) are analyzed. This explains to students the limited knowledge of ancient people, their scientifically incorrect conclusions based on their observations. Showing the principle of the historical development of knowledge - to show that human knowledge accumulates and improves over time. It is also emphasized that the secrets of the universe were gradually revealed due to the mutual communication of astronomers in different eras and countries, the exchange of manuscripts, and international cooperation (for example, in the work of Beruniy, Galileo, Kepler, and Newton). The uniqueness of the Sun is central to understanding the stars.Stars are huge balls of gas, mostly hydrogen and helium, that emit their own light and heat. The Sun is one such star. It does not appear larger or hotter than other stars; on the contrary, it appears larger and brighter than others because it is the closest star to us. The second closest star (Proxima Centauri) is 270,000 times farther away from the Sun. Light travels at a speed of 300,000 km per second. It takes about 8 minutes and 20 seconds for sunlight to reach Earth. This example introduces students to the concept of a “light year” – they begin to understand the relationship between distance and time.

All the planets in the solar system revolve around the Sun in their own paths, called orbits. The Sun’s gravity keeps the planets and other celestial bodies from scattering in different directions throughout space.

The closest planet to the Sun is Mercury. Then there are Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. The farther a planet is from the Sun, the longer its path, or orbit, and the longer its year, or the time it takes to orbit the Sun. Mercury revolves around the Sun in about three

Earth months, while Uranus revolves around it in 84 years. Many of the larger planets in the solar system have satellites. In addition, smaller objects such as comets and asteroids also orbit the Sun. There is also gas and dust in the interplanetary space in the solar system. In the region closest to the Sun, there are planets that contain a lot of iron, silicon and carbon. Today, we call them terrestrial planets. These are Mercury, Venus, Earth and Mars. Hydrogen and helium gases served as the main material for the formation of planets farther from the Sun. The surfaces of the planets Jupiter, Saturn, Uranus, and Neptune are not solid. They are larger than the terrestrial planets. These planets are called giant planets.

Mercury. The closest planet to the Sun, Mercury, is named after the ancient Roman god Mercury. Mercury (Atorud) is similar in appearance to the Moon, and its diameter is about one and a half times larger than the Earth's natural satellite. Sharp temperature differences are observed on the planet: the night temperature drops to −170 °C, and the daytime temperature rises to +400 °C. Mercury completes a complete revolution around the Sun in 88 Earth days, and rotates around its axis once every 58 days. Therefore, the duration of one day on the planet is about half a year or even longer. Mercury has almost no atmosphere, and its surface is covered with numerous cracks and craters formed as a result of ancient volcanic activity and collisions of meteorites and other small celestial bodies. The average distance of the planet from the Sun is about 58 million kilometers. Mercury is difficult to observe from Earth because it is located very close to the Sun, and is mostly hidden from view during sunrise or sunset. According to historical sources, even the great astronomer Nicolaus Copernicus was unable to directly observe the planet during his lifetime. Modern space exploration has significantly expanded scientific knowledge about Mercury. In 1974–1975, the US Mariner 10 spacecraft flew by Mercury three times and transmitted images of its surface to Earth. On March 29, 1979, this spacecraft came within 705 km of the planet, setting a record.

Venus (Zuhra) is the second planet from the Sun, named after the ancient Roman goddess of love and beauty, Venus. This planet is located at an average distance of 108 million kilometers from the Sun. When observed from Earth, Venus appears as a very bright celestial body visible during the morning and evening twilight. It is the third brightest object in the Earth's sky after the Sun and the Moon. Venus completes a complete revolution around the Sun in 225 Earth days, and its rotation period around its axis is 243 days. Therefore, the duration of one day on the planet is longer than a year. The planet has a very dense atmosphere, which makes it impossible to observe stars from its surface. Scientists who previously observed the clouds of Venus assumed that the conditions on its surface were similar to the geological and climatic conditions of Earth billions of years ago and suggested that plants could develop there. However, subsequent scientific studies have shown that these assumptions are incorrect. The atmosphere of Venus is mainly composed of carbon dioxide gas, and its clouds are composed of droplets of sulfuric acid. Acid rain is constantly observed on the planet, and the average temperature is about +470 ° C. Due to such extreme conditions, even the simplest plant forms cannot exist on Venus. Many new scientific data about the surface of Venus were obtained using spacecraft. The first probes dropped to the planet by parachute could not withstand the effects of high atmospheric pressure and quickly failed. This once again confirms the extreme harshness of the physical conditions on Venus.

Earth and the Moon**.** Earth is the third planet in the Solar System, with an average distance of about 150 million kilometers from the Sun. The Earth rotates on its axis once every 24 hours, and revolves around the Sun once every 365 days. The planet appears as a blue ball from space, which is explained by the fact that most of its surface is covered with water and is surrounded by an atmosphere - a gas shell. Earth is the only planet in the Solar System where life has been found.

The planets Mercury and Venus do not have natural satellites, but all planets after Earth have natural satellites. A satellite of a planet is a celestial body that orbits a planet, and it moves around its planet just as the planet revolves around the Sun. The Earth's only natural satellite is the Moon. The Moon completes a complete revolution around the Earth in about 28 days, and also rotates once around its axis in almost the same time. Therefore, when observed from Earth, only one side of the Moon is visible, and its opposite side has been studied only through space exploration. The diameter of the Moon is four times smaller than the diameter of the Earth, and its mass is 81 times less than the mass of the Earth. There is no atmosphere on the Moon. The main part of the Moon's surface is made up of mountain ranges, and the lowlands between them are historically called "seas", but there is no liquid water in these areas. The Moon does not emit light on its own, but reflects the Sun's rays. The phases of the Moon vary depending on its location relative to the Earth and the Sun and the angle of incidence of the Sun's rays. As a result, the observer sometimes sees a full Moon, sometimes a half Moon, and sometimes a crescent. These phases are called lunar phases in astronomy, and they change regularly over a period of about 28 days. The average distance between the Moon and the Earth is 384,400 kilometers. Although the Moon is located at a great distance from the Earth, it has a significant impact on natural processes on our planet. In particular, its gravitational effect causes periodic rises and falls in the water level in the oceans and seas - diurnal fluctuations in water (tidal phenomena).

The planet Mars has been observed by mankind since ancient times. This planet occasionally appears in the sky as a bright golden-reddish object. Mars is the fourth planet in the Solar System. Because of its reddish ("bloody") appearance, the ancient Greeks named it after the god of war Ares. In Roman mythology, the god of war was called Mars, and the planet's name comes from this name. Mars is located on average 228 million kilometers from the Sun. It is about half the size of Earth, and its mass is ten times less than the mass of the Earth. A year on Mars is 687 days, which is about two years on Earth. The planet rotates around its axis in 24 hours and 37 minutes, which is close to an Earth day. Mars has two natural satellites, which were discovered using a telescope in 1877. These moons are called Phobos and Deimos. Their names are derived from the Greek words for "fear" and "horror," respectively, and are attributed to the god of war. Phobos orbits closer to Mars, while Deimos orbits farther away. The Martian moons are not spherical like Earth's Moon, but rather oblong, resembling a potato due to their uneven shape. Phobos has a large crater on its surface, called Stickney Crater. Deimos is about 15 kilometers in diameter, while Phobos is 27 kilometers, which is very small on a cosmic scale. According to scientific assumptions, these moons may have originally been asteroids and were captured by Mars' gravity. Their surfaces are covered with craters and irregularities formed by numerous meteorite impacts. Of particular scientific interest are the strange ridges observed on the surface of Phobos. These ridges were detected in images taken by American spacecraft, and their causes have not yet been fully scientifically explained.

Jupiter is the fifth planet in the Solar System, named after the Roman god Jupiter. The average distance from the Sun is 778 million kilometers. Jupiter is a giant planet, with a diameter about 11 times the diameter of the Earth and a mass 118 times that of the Earth. Jupiter rotates very quickly on its axis: its day is 9 hours and 55 minutes. Its orbital period around the Sun is 12 years. The planet is visible in the Earth's sky as a very bright celestial body and sometimes appears as a star. Jupiter is a gas giant, meaning it has no solid surface. The planet is composed mainly of hydrogen and helium gases, and its atmosphere is covered with colorful cloud layers. These clouds are formed as a result of complex dynamic processes and surround the planet in the form of wide bands (zones and belts). These bands are caused by gas streams moving at different speeds. One of the

most notable objects in Jupiter's atmosphere is the Great Red Spot. This giant atmospheric phenomenon has been observed by astronomers for at least 300 years. Its size is several times larger than the diameter of the Earth, and it is interpreted as a powerful and long-lasting anticyclone - a huge storm with a large mass. As a result of studies conducted in 1979, it was revealed that Jupiter has a ring system consisting of tiny dust particles. This ring structure is similar to the famous rings of Saturn, but has a much fainter and more delicate structure. Jupiter's rings are believed to have formed mainly from dust particles released from the surfaces of its moons as a result of meteorite impacts.

Saturn (Zuhal) is the sixth planet in the Solar System. The average distance between it and the Sun is approximately 1,043 million kilometers. The planet is named after the ancient Roman god of fertility, Saturn, and in mythological sources he is described as the father of Jupiter and other gods. Saturn rotates completely around its axis in 10 hours and 40 minutes, which indicates its very rapid rotation. The planet revolves around the Sun once in approximately 29.5 Earth years (i.e., almost 30 years). Like Jupiter, Saturn is a gas giant. It consists mainly of hydrogen and helium, and its outer part is covered with a dense layer of gas - the atmosphere. The existence of layers of liquid hydrogen under high pressure and temperature under the atmosphere is scientifically proven. Complex meteorological processes are also observed in Saturn's atmosphere. It has huge storms and strong winds, which can be observed even from Earth with the help of modern telescopes. In some cases, these storms manifest themselves in the form of global-scale eddies. After the invention of the telescope, astronomers discovered one of the unique features of Saturn - its ring system. First observed by the Italian scientist Galileo Galilei in 1610, these rings were later studied in more detail. Saturn's rings are extremely extensive, their total width is several tens of thousands of kilometers, but their thickness is limited to only tens of meters (about 50 meters). The ring system consists of several independent rings that surround the planet without directly touching each other. These rings are mainly composed of ice particles and small pieces of rock. These particles can range in size from microscopic dust to objects several meters across. The high reflectivity (albedo) of the rings indicates that they are rich in ice. Various scientific hypotheses have been put forward throughout history about the origin of Saturn and its ring system. In particular, one of the hypotheses put forward by the Russian scientist Konstantin Tsiolkovsky suggested that the rings could be controlled by some intelligent forces. However, modern astronomy does not consider this idea to be scientifically sound. According to current scientific views, Saturn's rings may be the remains of a cloud of gas and dust that once surrounded the planet. Natural satellites formed from the outer parts of this cloud, while the inner parts were broken up under the influence of gravitational and dynamic processes, forming the current ring system. Thus, Saturn's rings are considered a unique astronomical object that reflects important stages in the planet's evolution.

Uranus is the seventh planet in the Solar System, with an average distance of about 2,087 million kilometers from the Sun. The planet is named after the Greek god of the sky, Uranus, who is depicted as the consort of the Earth goddess Gaia. Uranus is a gas giant. It is about 61 times larger than Earth and 15 times more massive than Earth. The planet completes an orbit around the Sun once every 84 Earth years. Its rotation period is 17 hours, indicating that it rotates rapidly. Since Uranus is so far from the central star of the Solar System, the Sun appears as a bright star-like point rather than a disk. The planet receives about 400 times less solar radiation than Earth. Therefore, its atmosphere may be constantly dimly lit, with a dark atmosphere. Uranus has no surface structure, as it consists of gaseous layers. Under its atmosphere are layers of gases compressed under high pressure, in particular hydrogen, helium and icy compounds (water, ammonia, methane). Under these layers, there is probably an "ocean" of liquid and dense

substances, and in the center of the planet there is a solid core of rock and iron. This structure is also typical of other giant planets. Uranus has many natural satellites, more than a dozen in number. The largest and relatively distant satellites, Oberon and Titania, were discovered by astronomer William Herschel, who discovered the planet in the 18th century, using a telescope. Later, in the 19th century, Umbriel and Ariel were discovered, and in the 20th century, Miranda and many other satellites were discovered. As a result of observations conducted in 1977, it was determined that Uranus has a ring system. These rings are similar in structure to those of Saturn, but are relatively faint and narrow. In 1986, the Voyager 2 spacecraft, during its study of the Uranian system, discovered dozens of small moons among the rings and large moons.

Neptune is the eighth planet in the Solar System, named after the ancient Roman god of the sea, Neptune. It is not visible to the naked eye from Earth, but can be seen with modern optical instruments, particularly powerful telescopes. The average distance between Neptune and the Sun is about 4.5 billion kilometers. It is the fourth and outermost planet in the gas giants, which are often referred to as the outer planets of the Solar System. Neptune rotates on its axis in about 16 hours, which is short compared to a day. The planet takes 165 Earth years to complete a full orbit around the Sun. It is composed mainly of hydrogen, helium, and methane, and it is the methane that gives the planet its characteristic blue color. Complex and dynamic processes are observed in Neptune's atmosphere. Astronomers occasionally detect cloud systems and vortices of various shapes in its atmosphere. These formations are characterized by the appearance and subsequent disappearance of these formations. Scientifically, these phenomena are explained by strong storms and atmospheric currents. Neptune also has large atmospheric spots, like Jupiter. For example, the Great Dark Spot is a huge storm system, close to the size of the Earth, which is observed surrounded by white clouds. Neptune's natural satellites are also of scientific interest. The largest satellite, Triton, was discovered shortly after the planet was discovered. Nereid was also discovered later. In 1989, the Voyager 2 spacecraft studied the Neptune system, discovered several more satellites, and transmitted their images to Earth. Triton is one of the most interesting objects in the Neptune system. It has a thin atmosphere, with coatings consisting mainly of nitrogen ice in the polar regions. Under the influence of solar radiation, this ice partially evaporates, forming cryovolcanic geysers that rise to a height of 8–10 kilometers. This phenomenon indicates that there are active geological processes on the surface of Triton. Neptune, with its remote location, complex atmosphere and interesting moons, is one of the most mysterious and poorly studied planets in the Solar System.

In conclusion, the planets in the Solar System differ significantly from each other in their structure, physical properties and laws of motion. The inner planets - Mercury, Venus, Earth and Mars - have solid surfaces, while the outer planets - Jupiter, Saturn, Uranus and Neptune - are giant bodies with a mainly gaseous structure. Each of the planets has its own unique characteristics: some have sharp temperature differences, while others have strong atmospheric phenomena, huge storms or ring systems. Natural satellites are an integral part of the planets, which also have their own structure and properties. In particular, the only satellite of the Earth - the Moon - has a significant impact on the natural processes on our planet. As a result of modern space exploration, humanity is gaining more and more in-depth knowledge about the planets. The information obtained with the help of various spacecraft has not only enriched existing ideas, but also raised new scientific questions. Therefore, the process of studying the Solar System continues continuously and is of great importance in understanding the secrets of the universe.

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