

University Planetariums and Observatories: The Critical Role of Higher Education in Future Studies

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In the article, the authors reviewed the main functions of the university planetariums and observatories in higher education. When considering higher education in Plato's tradition, the authors found that in addition to the three generally recognized functions, there is a fourth, perhaps the main function of the university planetariums and observatories. They form the planetary and cosmic thinking, i.e. person's spatial awareness on a scale of Earth and the cosmos. In fact, the university planetariums and observatories lay the foundation for the arête of a modern man: the inextricable link between the inner essence of a person and the space. They expand a person's world view from a regional and even planetary scale to the perception of the self as a product of cosmic processes, thus laying the foundation for the ontological orientation of individual self-realization to future studies.

Keywords: university planetariums, university observatories, higher education, university students, future studies, arête, Plato's tradition

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Introduction

Tom Kwasnitschka in the journal *Nature* published an article in which he proved that the naive notion that planetariums could not offer anything to scientists was a thing of the past. According to Kwasnitschka, modern planetariums have long ceased to be a place where schoolchildren are attracted for whizzy trips through the stars [Kwasnitschka, 2017]. The modern digital equipment of the planetariums is designed “to visualize the most complex astronomical data sets gathered so far and thus explore ideas about the distribution of galaxies, exoplanets and the make-up of comets.” According to the International Planetarium Society (IPS), there are around 1,300 digital domes in operation globally, each measuring between 3 and 30 meters across all academic facilities. Kwasnitschka believes that planetariums can display the “visualizations of neuronal activity, Hurricane Katrina, particle collisions from the Large Hadron Collider, marine food webs along the US Northwestern Pacific coast, and the magma chamber under the Yellowstone Plateau in Wyoming” [Kwasnitschka, 2017].

Cumhur Türk and Hüseyin Kalkan conducted a study and proved that “teaching astronomical concepts in a planetarium environment¹ was more effective than in a classroom environment. The study also revealed that students in the planetarium-assisted group were more successful in comprehending subjects that require 3D thinking, a reference system, changing the time and observation of periodic motion than those in control group” [Türk & Kalkan, 2015].

Roger Hutchins in the book “British University Observatories 1772–1939” substantiated the important role of university observatories in the exploration of the Universe. Hutchins identified the location of six British university observatories (ranging north to south from Glasgow, Durham, and Dunsink to Cambridge, Oxford, and London university observatories) “between the great national observatories like Greenwich and Paris and those of the grand amateurs like Lord William Rosse and William Huggins” [Hutchins, 2008]. In his study, Hutchins argued that despite the existing internal competition, it was this class of observatories, which jointly trained the post–World War II leadership in British astronomy. The book shows that university observatories do not only fulfill an educational mission, but also make an important contribution to scientific research in astronomy and astrophysics.

In this article, the authors will consider the peculiarities of the influence of the university planetariums and observatories on university students. The authors will review the higher education in Plato’s tradition and provide answers to two questions:

1. How far is the construction of planetariums and observatories on the campus necessary?
2. How do university planetariums and observatories affect future studies?

The role of planetariums and observatories in higher education

In fact, planetariums and observatories have different goals when organizing their activities. Planetariums are primarily theatres, which provide educational or entertainment shows about the stars and the universe. This is visualizing of the complex structure of the universe in an exciting and informative space travel. For this reason, the main characteristics of a planetarium are the following: a) the size of the dome-shaped projection screen (or the celestial scenes);² b) the technologies that are used to simulate the sky; c) the number of

¹ The study sample included seventh-grade (12–13 years old) students.

² Planetariums range in size from the 37 meter dome in St. Petersburg, Russia to three-meter inflatable portable domes where attendees sit on the floor.

seats.³ The International Planetarium Society, which brings together nearly 500 members who come from 50 countries around the world, advocates the following values: science as a way to understand the world; Inclusivity of and respect for cultures; sharing knowledge; openness to discovery and new ideas; service excellence; leadership in our field [International, 2019].

Observatories are research centers where painstaking observation of terrestrial or celestial processes and phenomena is conducted. These are scientific studies of the past, present and possible future of Earth and the Universe. Currently, there are the following types of observatories:

1. Astronomical observatories, which are divided into four categories: space-based, airborne, ground-based, and underground-based. For example, in the book “Small Astronomical Observatories”, Patrick Moore described the features of creation and the effectiveness of using amateur and small professional observatories [Moore, 2012]. Among modern large astronomical observatories, the following can be identified as an example. In the article “The Simons Observatory: Science Goals and Forecasts”, the authors describe the Simons Observatory as a new cosmic microwave background experiment (Cerro Toco, Chile). The Simons Observatory plans to start work in the early 2020s. The authors of the article describe the scientific goals of the experiment, motivate the design, and forecast its performance [Ade et al., 2019].
2. Volcano Observatories. Amy R. Donovan, Michael Bravo, and Clive Oppenheimer, using the example of the Montserrat Volcano Observatory, describe a complex dialogue that took place between scientists and officials when preparing for construction and during the operation of a volcanic observatory. This dialogue involved contested understandings of the role of volcano observatories, and the balancing of limited resources within and beyond the observatory [Donovan et al., 2013].
3. Atmospheric Observatories. For instance, the article “Clouds at the Arctic Atmospheric Observatories” describes the results of a decade-long work of a network of Arctic atmospheric observatories [Shupe et al., 2011]. Observatory sites are located in Alaska, Canada, Greenland, Svalbard, and the western Arctic Ocean. Studies were conducted to characterize the Arctic cloud occurrence, macrophysical properties, and persistence.
4. Physical observatories. The history of the origin and significance of physical observatories in scientific research of the 19th century is described in the book “The Heavens on Earth: Observatories and Astronomy in the Nineteenth-Century Science and Culture” [The Heavens, 2010]. In the article “Observation of Gravitational Waves from a Binary Black Hole Merger”, the authors describe the features of the work of a modern physical observatory: Laser Interferometer Gravitational-Wave Observatory (LIGO). Namely, on September 14, 2015 at 09:50:45 UTC the two detectors of the Laser Interferometer Gravitational-Wave Observatory simultaneously observed a transient gravitational-wave signal [Abbott et al., 2016].

In general, planetariums specialize in the popularization of astronomy and astrophysics among the population, and the observatories — in the scientific study of the processes and phenomena on Earth (e.g., in the field of meteorology, geophysics, oceanography, volcanology, etc.) and in the Universe.

In higher education, the fundamental differences between planetariums and observatories are fading. The university planetariums, in addition to cognitive shows devoted to the past,

³ For example, the Birla Planetarium in Kolkata, India has a capacity of 630 seats, the China Science and Technology Museum Planetarium in Beijing, China has 442 seats.

present and future of the Earth and the Universe, are used to teach courses in astronomy, astrophysics and other disciplines. The equipment of the planetariums allow to expand the perception of the theoretical material, to carry out testing of cosmological models, to independently investigate conceptions of the cosmos, etc. For example, the Charles W. Brown Planetarium (Ball State University, Muncie, USA) has five telescopes. The largest and most effective of these is the 16-inch Meade LX200 telescope, which allows students to independently create new stars, observe the evolution of the Universe, and carry out the Milky Way and intergalactic travels [Charles, 2019]. Further, in addition to complex scientific research, the university observatories are used to teach certain courses of lectures, e.g. on cosmology, oceanography, geophysics, etc. Students have the opportunity to acquire theoretical knowledge and practical skills in researching current scientific problems of the evolution of Earth and the Universe. In observatories, communication is carried out between research scientists and university students, between the ideas and skills of an experienced professor and a young researcher who is only choosing his own path in life. For example, the Prescott Observatory Complex (Embry-Riddle Aeronautical University, Prescott, USA) consists of two observatories: Optical Observatory and Radio Observatory. The Observatory Complex website provides the following information: “Used for Astronomy classes and a wide variety of short-term and long-term undergraduate student/faculty projects in Optical and Radio Astronomy. Typically 6-10 student projects in progress at any given time. Also used for public outreach in Astronomy, either on-site or via video streaming to the Planetarium” [Prescott, 2019].

In higher education, the university planetariums and observatories perform three main functions:

1. Expand knowledge of the evolution of Earth and the Universe.
2. Form the necessary set of competencies for professional research work.
3. Involve university students in the process of researching current scientific problems, thereby arousing and reinforcing their interest in research work.

Universities, governments and individuals invest large amounts of money into the construction of planetariums and observatories, as well as the renovation of their equipment. For example, construction costs of the Ronald G. Eaglin Space Science Center (Morehead State University, USA) amounted to \$ 15.6 million. This is the heart of MSU’s Department of Earth and Space Sciences. “The two-story, state-of-the-art building encompasses 45,000 square feet of floor space and includes a control center for the 21-meter space antenna system on the ridge top above Nunn Hall; RF and electronics laboratories; anechoic chambers that mimic the electromagnetic environment of space; a rooftop antenna test range; a space systems development laboratory and a digital Star Theater” [Space Science Center, 2019]. The construction of the Keck Observatory (Mauna Kea, Hawaii) began with the first instalment of the W. M. Keck Foundation, which amounted to \$ 70 million. Originally, the Keck Observatory was managed by the University of California and the California Institute of Technology. Today, the Keck Observatory is supported by both public funding sources and private philanthropy. The organization is managed by the California Association for Research in Astronomy (CARA), whose Board of Directors includes representatives from the California Institute of Technology and the University of California, with liaisons to the board from NASA and the Keck Foundation [W. M. Keck Observatory, 2019]. The total cost of the project exceeds \$ 140 million. The W. M. Keck Observatory is a two-telescope astronomical observatory. Both telescopes feature 10 m (33 ft) primary mirrors, currently among the largest astronomical telescopes in use.

High-tech university planetariums and observatories allow not only to educate outstanding astronomers, cosmologists, physicists, etc., but also to attract outstanding researchers to universities. For example, Herbert Hall Turner, a famous British astronomer and seismologist, resigned from the Royal Greenwich Observatory and became the Director of the Radcliffe Observatory at Oxford University. He headed the university observatory for 37 years. During this period, Turner created the Astrographic Catalogue, discovered and researched deep focus earthquakes, and made other important scientific discoveries in the field of astronomy and seismology [Hutchins, 2008]. In 1932, Harry Hemley Plaskett succeeded Herbert Turner as Savilian Professor of Astronomy at the University of Oxford. Over 28 years of his work in the Radcliffe Observatory, Plaskett made significant contributions to the fields of solar physics, astronomical spectroscopy and spectrophotometry.

University planetariums and observatories create the conditions for full-fledged scientific research. The studies by Steven J. Dick and Roger Hutchins allow us to compare observatories that are subordinate to governments and universities [Dick, 2002; Hutchins, 2008]. Paying tribute to both classes of observatories, we can state that not always the amount of investment affects the effectiveness of research. University observatories are often more effective, even though their funding in most cases is inferior to the funding of observatories that are subordinate to governments and military departments.

The performance efficiency of planetariums and observatories is determined by ratings. There are many ratings that allow you to compare the effectiveness of university planetariums and observatories among themselves and with other classes of observatories. In evaluating the effectiveness, different methods are used. For example, in the U.S. higher education, the main methods of evaluation and ratings are set by the U.S. Department of Education. The basic mission of the Institute of Education Sciences is to provide scientific evidence on which to ground education practice and policy and to share this information in formats that are useful and accessible to educators, parents, policymakers, researchers, and the public [Institute, 2019]. The second example is presented by the Ranking Everything College website, giving the ranking of “The 35 Best College Astronomy Observatories.” In ranking the College Observatories, we considered the following data points: Number, Size, and Technology of Telescopes [The 35 Best, 2019].

Plato’s and Isocrates’ tradition in contemporary higher education

Oleg Bazaluk, in his article “The Strategies of Systematization of the Theories of Education”, reviewed the features of the development of the theories of education in the history of culture. He proposed to systematize them according to two development lines: Plato and Isocrates [Bazaluk, 2017; Bazaluk et al., 2018]. The fundamental difference between the two main lines of development is that the education theories of the Isocrates’ line focus on the ways of teaching, i.e. on the effectiveness of the transfer of special knowledge and competencies. The ways of transferring knowledge are becoming the subject of market relations, and Isocrates’ line education theories are turning into a driving force for the educational services market.

Plato’s tradition in education originates from Plato’s theory of education, which has been preserved to our times in the books “Republic” and “Laws” [Plato, 1994]. The main feature of this development line of the theories of education is that it considers education as a way of life. In the theories of education of Plato’s line, the focus is not on how to transfer knowledge, but on the features of arête formation. In contemporary philosophy, the ancient Greek notion of arête has become obsolete. Instead, synonyms are used: “worldview”, “self”,

“spirituality”, “psyche”, “mind”, etc. However, from our point of view, none of the listed terms fully disclose the wealth and scope of the meanings of the term “arête”.

In our opinion, one of the reasons why the term “arête” has become obsolete in modern theories of education is the predominance of purely philosophical meanings in it. The terms “worldview”, “self”, “spirituality”, etc., which are developed by modern Plato’s line theories, are based on the research in psychology and neuroscience. These disciplines use scientific methodology, not philosophical one. Bazaluk proposed to reanimate the term “arête” [Bazaluk, 2019]. In order to bring the philosophical meanings of the term “arête”, which we find in Plato and especially in Aristotle, closer to modern psychological and neurobiological theories, Bazaluk proposes to use the methodology of neurophilosophy [Bazaluk, 2019]. If we compare the approach of Bazaluk, e.g. with that of Hope May, then the first one seems more attractive. May tried to convey the meanings of Aristotle’s ethics in the language of modern psychological theories [May, 2010]. Paying tribute to the May’s knowledge of Aristotle’s writings and modern psychological theories, we join the group of critics who consider May’s attempt to be unsuccessful. Modern psychological theories cannot replace the philosophical concepts of Aristotle. Accordingly, the terms, with which May replaces the terms of Aristotle, lose the wealth of meanings, which are used by Aristotle to describe the events and phenomena related to human nature.

University Planetariums and Observatories as a way of forming arête

In Plato’s tradition, the term “arête” has the following, perhaps most important, meaning. This is an inextricable link between the inner essence of a person and the cosmos. This is an expansion of worldview from a regional and even global scale to the perception of the self as a product of cosmic processes. This is the nesting of the human essence in the cosmos, respectively, the ontological connection of human self-realization with cosmic processes. This is clear understanding of man’s place in the cosmos, and not in the religious meanings, but in the subject ones, as a given. The term “arête” does not have supernatural, sacramental, and theological meanings. For Paton, as for any Greek of that time period, the term “divine” was synonymous with the term “cosmos”, and the main meaning of the term “cosmos” is an order that started from the order of ideas generated by the brain to the order in the structure of the Universe.

The use of the term “arête” makes it possible to consider a person not only in terms of psychological and neurobiological theories. These theories perform defining tasks. However, the formation of “arête” as the human essence, as an interdisciplinary and all-encompassing knowledge about the place of a human in cosmic processes, becomes possible only by means of philosophy as the highest stage of education. In Plato’s tradition, philosophy is not an abstract discipline, just like education is not teaching. In Plato’s tradition, the term “education” is synonymous with the term “paideia”, in terms of which philosophy, as well as education, is a way of life. Paideia forms arête, creates it in a certain way. As a wood master turns a tree bar into a bird-like work of art, so a teacher forms an arête in his likeness, in the image that he represents in his student.

In Plato’s tradition, student’s knowledge and image are important actors in the educational process. However, the main role is played by the teacher who forms the arête of a student. It depends on the teacher how the formed student’s arête will correspond to their inner essence, and also how fully the inner essence of a student (arête) can be revealed in current social and economic relations. A teacher helps a student to determine the way of life, i.e. perceive their

place on a scale of society, Earth and the Cosmos. Forming *arête* of students is tantamount to expanding thinking to a planetary and cosmic scale. For this reason, planetariums and observatories are becoming an important tool for the formation of *arête*. They provide awareness of the nesting of ontogenesis in cosmic processes, as well as the ontological orientation of individual self-realization in accordance with the evolution of Earth and the Universe. The ability to think and be aware of their place on a scale of the Universe becomes the key competence that allows a student to measure their vital activity and to self-realize for the benefit of the future civilization.

Considering higher education in Plato's tradition reveals the fourth major function performed by the university planetariums and observatories. They form the planetary and cosmic thinking, person's spatial awareness on a scale of Earth and the Universe. In fact, they lay the foundation of the *arête* of modern human. University planetariums and observatories are becoming an important element of education, bringing it as close as possible to Plato's tradition. The formation of human awareness of self-nesting into cosmic processes creates the basis for future studies. Human self-realization is not commensurate with short-term goals and the solution of current problems, but global goals and long-term planning. This is a strategic foresight of personal future and personal contribution to the future of civilization. Thanks to the influence of the university planetariums and observatories, it is possible to investigate the underpinnings and research apparatus of law and economics, as well as to expose its opportunities to prevent a global financial crisis in the future [Lewkowicz, 2017]; to consider the issues of the necessity of dialogue and mutual understanding between different civilizational layers in national States and in inter-State relations [Yakushik, 2019]; exploration and use of the aerospace environment (Sky, Space) for survival and development of Earth civilization [Soroka & Syntichenko, 2018]; to carry out the research and mining of gas deposits on the moon [Slyuta, 2017]; etc.

The first doctoral program on the Study of the Future, was founded in 1969 at the University Of Massachusetts by Christopher Dede and Billy Rojas. Currently there are approximately 23 graduate and PhD programs in foresight globally, in which the university planetariums and observatories perform a key mission.

Conclusions

On this basis, we conclude that currently the university planetariums and observatories perform three main functions in higher education:

1. Expand knowledge of the evolution of Earth and the Universe.
2. Form the necessary set of competencies for professional research work.
3. Involve university students in the process of researching current scientific problems, thereby arousing and reinforcing their interest in research work.

However, if we consider higher education in Plato's tradition, we find the fourth, possibly the main function of the university planetariums and observatories: they form the planetary and cosmic thinking, i.e. person's spatial awareness on a scale of Earth and the Universe. In fact, they lay the foundation for *arête* of modern human, i.e. the inextricable link between the inner essence of a person and the phenomena and processes that occur in space. They expand a person's worldview from a regional and even planetary scale to the perception of the self as a product of cosmic processes, thus laying the foundation for the ontological orientation of self-realization to future studies.

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