

ASTROFOTOGRAFIJA KAO PROZOR U BESKONAČNOST: OTKRIVANJE ČUDA SVEMIRA KROZ OBJEKTIV

ASTROPHOTOGRAPHY AS A WINDOW INTO INFINITY: DISCOVERING THE WONDERS OF THE UNIVERSE THROUGH THE LENS

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SAŽETAK

Ovaj rad istražuje ulogu i potencijal astrofotografije u astronomskom obrazovanju, s posebnim naglaskom na njenu integraciju u formalne i neformalne obrazovne procese. Rad obuhvaća teorijski okvir astrofotografije, njezin doprinos znanstvenim otkrićima i suradnji između profesionalnih i amaterskih astronoma. Analizira se edukativna vrijednost astrofotografije u različitim obrazovnim kontekstima, kao i njen utjecaj na motivaciju učenika za STEM područja. Posebna pozornost posvećena je primjeni modernih tehnologija u astrofotografskom obrazovanju, uključujući mobilno učenje, proširenu stvarnost i virtualne planetarije. Rad također razmatra ulogu astrofotografije u cjeloživotnom učenju i njen doprinos popularizaciji znanosti kroz različite medije i javne događaje. Etička pitanja vezana uz autorska prava i svjetlosno onečišćenje obrađena su u kontekstu astrofotografije, a rad se zaključuje pregledom budućih trendova i potencijalnih obrazovnih inovacija u ovom području. Zaključci ističu značajan potencijal astrofotografije u povećanju interesa za STEM područja, razvoju praktičnih vještina i kritičkog razmišljanja. Preporuke obuhvaćaju razvoj strukturiranih kurikuluma, evaluaciju dugoročnih učinaka astrofotografskih programa, integraciju novih tehnologija i poticanje suradnje između obrazovnih institucija i astronomskih društava. Ovaj sveobuhvatan pregled astrofotografije u obrazovanju

pruža vrijedan uvid u njezin potencijal za transformaciju astronomskog obrazovanja i poticanje šireg interesa za znanost i tehnologiju.

Ključne riječi: astrofotografija, svemir, učenje, umjetna inteligencija, fotoaparat, teleskop, zvijezde

ABSTRACT

This paper explores the role and potential of astrophotography in astronomy education, with a particular emphasis on its integration into formal and informal educational processes. The paper covers the theoretical framework of astrophotography, its contribution to scientific discoveries and collaboration between professional and amateur astronomers. The educational value of astrophotography in different educational contexts is analyzed, as well as its impact on students' motivation for STEM fields. Special attention is paid to the application of modern technologies in astrophotography education, including mobile learning, augmented reality and virtual planetariums. The paper also considers the role of astrophotography in lifelong learning and its contribution to the popularization of science through various media and public events. Ethical issues related to copyright and light pollution are addressed in the context of astrophotography, and the paper concludes with an overview of future trends and potential educational innovations in this field. The conclusions highlight the significant potential of astrophotography in increasing interest

in STEM fields, developing practical skills and critical thinking. Recommendations include developing structured curricula, evaluating the long-term effects of astrophotography programs, integrating new technologies, and encouraging collaboration between educational institutions and astronomical societies. This comprehensive review of astrophotography in education provides valuable insight into its potential to transform astronomy education and foster broader interest in science and technology.

Keywords: *astrophotography, space, learning, artificial intelligence, education, ethics, light pollution, guidelines, camera, telescope, stars*

1. INTRODUCTION

The main goal of this paper is to explore the role and potential of astrophotography in astronomy education with a particular focus on its integration into formal and informal education processes. Specific aims include: application of astrophotography in formal and informal educational analysis, investigating the impact of astrophotography on students' motivation for STEM fields, identifying concrete examples of successful integration of astrophotography in educational programmes and assessing the potential of astrophotography in the context of lifelong learning.

Astrophotography is a powerful tool in astronomy but also in STEM education, combining technical skills with artistic expression and scientific research. Its importance is evident in several key aspects. Astrophotography can significantly increase students' interest in astronomy and STEM subjects in general. The visual appeal of astrophotography often serves as an initial stimulus to further explore astronomical topics. Astrophotography workshops such as "The Little School of Astrophotography" in Daruvar show how practical experience can spark a long-term interest in astronomy.

No extremely expensive astronomical and photographic equipment is necessary in order to engage in astrophotography. If you are already into photography, chances are you already have everything you need to get started in astrophotography today. [1]

2. THEORETICAL FRAMEWORK OF ASTROPHOTOGRAPHY

Astrophotography is defined as a branch of photography dedicated to capturing celestial bodies and phenomena, encompassing a wide range of techniques and subjects—from imaging the Moon and planets to distant galaxies and nebulae.

The history of photography goes back to the 19th century:

- 1839: Louis Jacques Mande Daguerre tries to photograph the Moon, but fails due to errors in tracking.
- 23rd March 1840: John William Draper takes the first successful photograph of the Moon using a 13-centimetre reflecting telescope and exposure time of 20 minutes. [2]



Figure 1 *The first successful photograph of the Moon [2]*

- 1845: French physicists Leon Foucault and Hippolyte Fizeau take the first photograph of the Sun
- 1850: William Cranch Bond and John Adams Whipple photograph the star Vega at the Harvard Observatory
- 1880: Henry Draper photographs the Orion Nebula with the exposure time of 51 minutes, which is the first photograph of a nebula ever taken

The development of digital photography towards the end of the 20th century revolutionised astrophotography by making it more accessible to amateurs and significantly improving the quality of the photos.



Figure 2 The Core of the Milky Way above the Chapel of St. Anthony on Zavižan [3]

3. TECHNIQUES AND EQUIPMENT IN ASTROPHOTOGRAPHY

Astrophotography encompasses various techniques depending on the subject and the desired result:

- a) Wide-Angle Astrophotography: Used for capturing large areas of the sky, including the Milky Way and meteors.
- b) Planetary Photography: Focuses on imaging the planets of the Solar System.
- c) Deep-Sky Photography: Aimed at capturing distant objects such as nebulae and galaxies.
- d) Solar Photography: A specialized technique for imaging the Sun.

3.1. "AN EXPENSIVE HOBBY" MADE ACCESSIBLE

Astrophotography equipment varies depending on the technique and subject being captured. Although many consider it an "expensive hobby," it's important to note:

One of the biggest misconceptions about astrophotography is that expensive, professional equipment is required to photograph the night sky. This is not true. Today, technology has advanced to the point where you can take astrophotos even

with an ordinary smartphone equipped with a camera, or with a camera and a kit lens. Such equipment is sufficient for beginners, but to photograph celestial bodies that are more distant and less illuminated, better equipment is still necessary.

A camera and a tripod are essential, as long exposures are required.

Detailed list of equipment:

- Camera: From DSLR cameras to specialised astronomical CCD cameras
- Telescopes: reflectors, refractors or catadioptric systems
- Mounts/trackers: For accurate tracking of space bodies
- Filters: Including filters for light pollution reduction
- Editing software: Photograph stacking and editing software



Figure 3 Small portable tracker MoveShootMove that does polar alignment [5]

3.2. TECHNOLOGY PROGRESS

For beginners, even a smartphone with manual settings can be sufficient for the first steps in astrophotography. However, for more advanced techniques and better results, specialized equipment such as astrophotography cameras with cooled CCD or CMOS chips is required.



Figure 4 A panorama of the Milky Way taken from the Vratnik pass [7]

Advances in technology continuously change the field of astrophotography, enabling the capture of ever fainter and more distant objects and expanding possibilities for scientific research and educational applications.

"It truly is a magical experience to stand outside at night and look at the stars. Today, thanks to advances in camera technology, it is easier than ever to go outside and capture the wonder of the night sky." [6]

4. THE ROLE OF ASTROPHOTOGRAPHY IN SCIENTIFIC RESEARCH

Astrophotography has played a key role in numerous astronomical discoveries, enabling scientists to study celestial objects and phenomena in detail that are often invisible to the human eye. For instance, astrophotography was instrumental in the discovery of the dwarf planet Pluto in 1930. [8]

4.1. CONTRIBUTION OF ASTROPHOTOGRAPHY TO ASTRONOMICAL DISCOVERIES

Objects that are too weak or too distant to be visible by direct observation can be detected using various techniques. Through them deep space can be explored, and those photographs enable astronomers to investigate distant galaxies and nebulae.

Thanks to the availability of advanced equipment, amateur astronomers can capture high-quality astrophotographs that often contribute to scientific research. [9]



Figure 5 Pleiades, known as the Seven Sisters, and in Croatia as Vlačići – captured above Krk. The distance of the Pleiades is about 440 light-years from Earth, and I managed to capture them with a Nikon d7200 camera and a Sigma Art 135mm lens [10]

Photographs taken by Hubble, as well as its successor James Webb, provide insight into the structure and evolution of the universe. Series of astrophotographs make it possible to track changes on planets, stars, and other celestial bodies over time. Modern astrophotography techniques, combined with advanced data processing algorithms, enable the detection and characterization of planets outside our Solar System.

4.2. COLLABORATION BETWEEN PROFESSIONAL AND AMATEUR ASTRONOMERS

Astrophotography is a field where collaboration between professional and amateur astronomers is particularly fruitful. Thanks to the availability of advanced equipment, amateur astronomers are

able to capture high-quality astrophotographs that often contribute to scientific research.

Over the past 30 years, a network of observatories has developed, and generations of experts have been trained to discover and monitor these bodies, as well as to predict and prevent the recurrence of such catastrophes.

To date, more than 19,000 objects are known and classified as “potentially hazardous,” with the number increasing each month by about 200 newly discovered bodies, and we are still far from completing such a list. [11]

The network of astronomers identifying objects with potential threats to our planet includes both professional and numerous amateur astronomers worldwide. This is an example of how informal education and hobbies can directly contribute to formal scientific work.

Astrophotography can be integrated into education through:

- Formal education: Inclusion of astrophotography projects in the science and technology curriculum. This may involve practical workshops, field trips to observatories, and long-term projects for monitoring celestial bodies.
- Informal education: Organizing astrophotography clubs, summer camps, and workshops that connect professional astronomers with students and amateurs.

These activities can be especially effective in encouraging long-term interest in STEM fields. For example, at elementary schools Mate Lovrak and Vladimir Vidrić, work with students has continued throughout the decade from 2000 to 2010.

Each year, about twenty young astronomers embark on their journey of space exploration from the schoolyard or the observatory. Teachers working with the younger grades include Anka Domitrović and Draženka Rendulić; in fifth, sixth, and seventh grades, Vlatka Vidiček Dam, Zoran Kustura, Goran Rebrača, and Ivan Štibilj are involved, while Branko Odobašić works with high school students. [12]



Figure 6 Matea Bukač, a student of Mate Lovrak Elementary School in Kutina, created a model of the Solar System in Kutina for the National Astronomy Competition in Omiš in 2016, inspired by the Grounded Solar System in Zagreb. [13]

5. MOBILE LEARNING AND AUGMENTED REALITY

Mobile learning represents a significant advancement in integrating astrophotography into education. Modern mobile applications enable students to engage in astrophotography using devices they already possess, making this discipline more accessible.

5.1. STELLARIUM – STARS IN THE PALM OF YOUR HAND

A very useful (and free, which is certainly welcome) mobile application called Stellarium stands out. It vividly displays sky maps according to the date and GPS location, and makes it possible to shift the “viewing time” forward, allowing users to plan astronomical observation or astrophotography sessions in advance.

Stellarium works by simply raising your mobile phone toward the night sky, and on the screen, you see the names of stars, galaxies, and even constellations, drawn according to the figures or animals they’re named after. For example, it becomes very clear why the Big Bear (Ursa Major) is named as such—the stars it contains are connected to form the actual outline of a bear.



Figure 7 Screenshot from the Stellarium application

In this way, the Stellarium application provides an interactive learning experience about the universe and the Solar System, combining astrophotography with educational content.

5.2. APPLICATION OF AUGMENTED REALITY IN ASTROPHOTOGRAPHY EDUCATION

Augmented reality (AR) opens new possibilities for the visualization and interaction with astronomical objects. AR applications can display the positions of celestial bodies in real time, helping students plan astrophotography sessions. Interactive 3D models of planets and galaxies can be projected into the real environment, providing students with a better understanding of the structure and scale of astronomical objects.

Virtual planetariums also represent a powerful tool for astrophotography education. Students can practice astrophotography techniques in controlled virtual conditions before working with actual equipment. Through the power of interactive presentation, virtual planetariums can display astrophotographs in an immersive environment, sparking students' interest in astronomy. One of the most successful examples

is certainly the planetarium of the Nikola Tesla Technical Museum in Zagreb.

In addition, the mobile application Photopills is very useful; similar to the previously mentioned Stellarium, it is extremely helpful for planning visual observation or photographing the night sky. Photopills is even more illustrative, as it uses augmented reality-through your phone's camera, it overlays diagrams and graphics of the night sky, making it very easy to determine where the Milky Way or Polaris will appear in relation to the landscape.

These modern technologies not only make astrophotography more accessible to a larger number of students, but also provide new, interactive ways to explore and understand the universe, fostering a long-term interest in STEM fields.

6. CONCLUSION

Astrophotography plays a significant role in lifelong learning, providing opportunities for continuous education and skills development at all stages of life.

Recommendations for future research and practical application:

- **Curriculum development:** It is necessary to develop structured curricula that integrate astrophotography into existing STEM subjects, with an emphasis on an interdisciplinary approach.
- **Evaluation of long-term effects:** Conduct longitudinal studies to assess the long-term impact of astrophotography programs on STEM career choices.

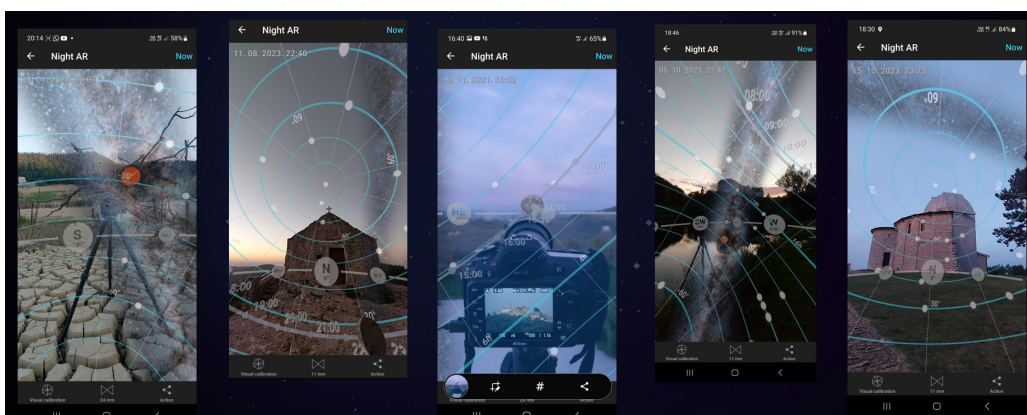


Figure 8 Examples of astrophotography planning with the Photopills application

- **Adaptation to different age groups:** Explore how to adapt astrophotography activities for various age groups, from primary school onward. Astrophotography plays a significant role in lifelong learning, providing opportunities for continuous education and skills development at all stages of life.
- **Integration of new technologies:** Investigate the possibilities for integrating artificial intelligence and augmented reality into astrophotography education.
- **Professional development for teachers:** Develop training programs for teachers to effectively use astrophotography in teaching.

Based on the analysis in chapters four and five, this paper makes a significant contribution to understanding how astrophotography can serve as a bridge between scientific research and educational practice. Through examples of successful collaboration between professional and amateur astronomers, it has been shown that astrophotography enables the active involvement of the wider community in scientific processes, thereby encouraging interest in astronomy and STEM fields.

At the same time, the application of mobile and portable digital devices, as well as augmented reality, points to new possibilities for interactive education that allow students and teachers to connect more deeply and personally with the universe.

This paper integrates recommendations from the literature and concrete examples from practice, highlighting the need to develop modern, technologically supported curricula that unite science, technology, and creative expression.

By implementing these recommendations, astrophotography can become an even more effective tool for stimulating interest in STEM fields and for developing key skills needed in the 21st century.

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Hayan Petroleum Company (HPC) iz Sirije, Marina Co. iz Egipta i INAgip Sjeverni Jadran. Bavi se proizvodnim inženjerstvom nafte, plina i geotermalne vode i stimulacijama ležišta i nositelj je više kolegija na prijediplomskom, diplomskog i poslijediplomskom studiju. Autor je i suautor više tehnoloških inovacija iz područja naftnog rudarstva za vrijeme rada u INA-i. Pročelnik je Sekcije za naftno rudarstvo i geoenergiju Znanstvenog vijeća za naftno-plinsko gospodarstvo i energetiku pri Hrvatskoj akademiji znanosti i umjetnosti, predsjednik je hrvatskog ogranka međunarodnog Društva naftnih inženjera (SPE) i predsjednik Hrvatske udruge za geotermalnu energiju (HUGE). Danas je izvanredni profesor na RGN-u, na kojem trenutačno obnaša i funkciju dekana fakulteta u već drugom mandatu.

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