Space, Astronomy Astrophotography

For teachers and students, with teaching material, evaluations, and examples of implementation.

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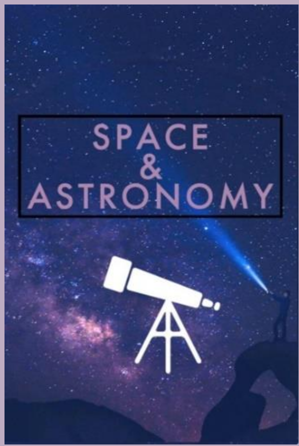
Voices Of the World

2021-2-BE02-KA210-SCH-000051180



Erasmus+ School Education Project

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2021-2-BE02-KA210-SCH-000051180

Mobility Trainings held in:

Brussels / Nevşehir / Tenerife

Project dates:

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2 Introduction

The project of space and astronomy was inspired by our personal memories of studying space and the planets during our school years in the 80's and 90's. Back then, we did not have the access to technology we have today, however, it was still just as fascinating.

With a decrease in the number of European students interested in STEM subjects, the study of space and astronomy with an artistic touch on photography, seemed like a great way to stimulate their curiosity.

A study conducted by the Department of Astrophysics and Geophysics, University of Liège (Naze et al, 2005) and KU Leuven, shows how teaching astronomy in schools can inspire students to study physics.

Through the opportunity that Erasmus+ education programs offer to educators and students, this project aims to suggest a teaching methodology that would not only foster students' interest in space, science, and technology but also liberate young people from the idea that STEM subjects are only for geniuses or can only be understood by a certain type of student. It also demonstrates and shares how the arts and science can be connected.

This E-magazine is a combination of our training material, methodology and implementation methods advised for and made accessible to teachers and students. It also includes an evaluation of how the students and teachers perceived the methodology and how they would incorporate it in their curriculum.

Project Implementation

The project held three trainings with teachers and students in which the objective was to teach about Space and Astronomy via the eye of the astrophotographer, and by assisting students to understand STEM disciplines and their options in physics, engineering, technology, and math. The training involved practical training through interactive demonstrations to get students involved in understanding how cameras, telescopes, and light works.

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The teachers participating were invited to learn and contribute as educators on to how best to integrate the teaching methodology suggested into the school curriculum.

The coordination of the project was done by ‘Voices of the World’, a Brussels based non for profit organization that collaborates with schools, universities, governmental and non-governmental organizations to integrate modern methodologies into the educational systems.

Two schools were invited to join this project:

1. An all-girls public high school in Nevşehir, Turkey, that aims to encourage more female and underprivileged students in STEM subjects and that is also open to many refugees, where our first training took place.
2. A public school from the Tenerife Island, Spain, open to students from various backgrounds and aiming at creating a better future through additional VET courses. The second training took place there, with the access to the amazing astrophysics centre, the Instituto de Astrofísica de Canarias (IAC), and the famous observatory park in Tenerife Island, an extreme added value to our project and an incredible experience for the students and teachers alike.

Our third training took place in Brussels, the city of the European headquarters. In this training we were able to combine the astronomy and physics training with arts but working on photo editing. The trainings were provided by our physicist colleague Dr. Marco Pezzutto.

The training covered the following three categories:

1. Theoretical teaching of general understanding of physics, astronomy, light, engineering of camera and engineering of telescope.
2. Practical teaching of assembling camera and telescope, adjusting to light, using the telescope for stargazing, astrophotography – that is namely how to use a camera to take pictures of the stars.
3. Practical training on professional photo editing using photoshop or Gimp.
4. Holding a photo gallery of the edited astrophotography done by teachers and students who participated in the trainings.

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Our trainings were based on both the theoretical discourse of physics, understanding physics, the categories of physics, and how the study of physics leads to several kinds of sciences and technology. Also, since we were teaching the engineering of the camera and telescope, a theoretical study about light was essential to cover for a better understanding of how the camera or telescope is engineered to adjust to light. We discussed the different telescopes that exist in today's technology to be able to see our galaxy. However, the most exciting part of the training were the practical parts.

The following chapters illustrate more in detail about the 'Space and Astronomy' project and methodology, accompanied by links and suggestions on how to incorporate space, astronomy, and even astrophotography in your school curriculum. The partner schools have also shared their individual experiences and on how they have implemented the project in their schools.

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3 Training Material for teachers

Note: you can click on any of the *blue underlined* text to open the link.

3.1 Theoretical approach

3.1.1 Physics and the scientific method


Figure 1: The Andromeda Galaxy.

The study of space and astronomy provides an excellent first approach to *physical sciences* and the scientific method, which comprises performing *observations* of physical phenomena, formulation of *hypotheses* about them in a *mathematical language*, and testing such hypotheses through further observations and *experiments*. Experiments and theory, technology and mathematics must go hand in hand for us to extend our understanding of the world we live in, and when successful, scientific discoveries should not only extend the range of our *knowledge*, but also empower us by enabling new *technologies* and bringing *wellbeing* to the whole of humanity.

Physics is the branch of science concerned with discovering and understanding the *fundamental constituents of the physical world* we live in, and its *inherent governing laws*. While the method of study and research is quite uniform, its domains of application vary widely, covering as much as possible the variety of phenomena that constitute our physical world. Different branches of physics include:

- *Mechanics*: motion and dynamics.
- *Thermodynamics*: heat, work, and energy.
- *Electromagnetism*: electrostatics, magnetism, currents, electromagnetic waves.
- *Atomic and molecular physics*: the structure of the atom and how atoms combine into molecules.
- *Nuclear physics*: the structure of the atomic nucleus, nuclear energy and nuclear reactions.
- *Particle physics*: studying the basic building blocks of our physical reality, and their interactions.

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- *Fluid dynamics*: the flow and dynamics of fluids.
- *Earth physics*: the atmosphere, weather, and earthquakes.
- *Solid state physics*: understanding the basic properties of different materials from their fundamental components (atoms and molecules).
- *Astrophysics and cosmology*: the physics of astronomical objects, and the dynamics and evolution of the Universe as a whole.

3.1.2 Observing and studying Space

In this project we developed a training that integrates *theoretical lectures* with *practical hands-on sessions* about space, astrophysics, astronomy, and astrophotography.

The *sky* has always been a source of wonder, mystery and discoveries for humanity, and has always been the object of studies from the earliest onsets of civilization. Our understanding of space and the universe started with *bare-eye observations* carried out for centuries since the ancient civilizations, improved substantially with the invention of *telescopes* and the development of the *scientific method* in the 17th century, until achieving the depth of contemporary astronomy and astrophysics through modern telescopes and s*pace missions*, space telescopes, satellites and probes sent across the Solar system.

3.1.3 Astronomy and Astrophysics


Figure 2: Photograph of the Moon taken with a telescope.

Astronomy is the branch of science devoted to the observation, study and understanding of space and everything contained in it: the Solar System, our own Earth's motion in space, other stars near and far from us, galaxies such as the Milky Way, and so many more amazing objects such as black holes, supernovae, nebulas etc. Astronomy relies mostly on observations of space, carried out with a huge variety of telescopes and instruments: from conventional Earth telescopes to radio telescopes, to space telescopes such as *Hubble*, to even more exotic instruments placed in satellites for measuring the spectrum of radiations, light and particles that come to us, travelling immense distances across space.

Current day astronomy is a very advanced field from both the scientific and the technological aspects; besides, it also enjoys a huge following of amateur enthusiasts across the whole world. In fact, many beautiful objects in space are accessible with small and medium sized telescopes. For example, if you are willing you can enjoy direct views of the planets in the Solar System with just a modest investment of time and resources. Great resources to get started can be found in abundance, for example in the YouTube channels by Forrest Tanaka and Dylan O'Donnell.

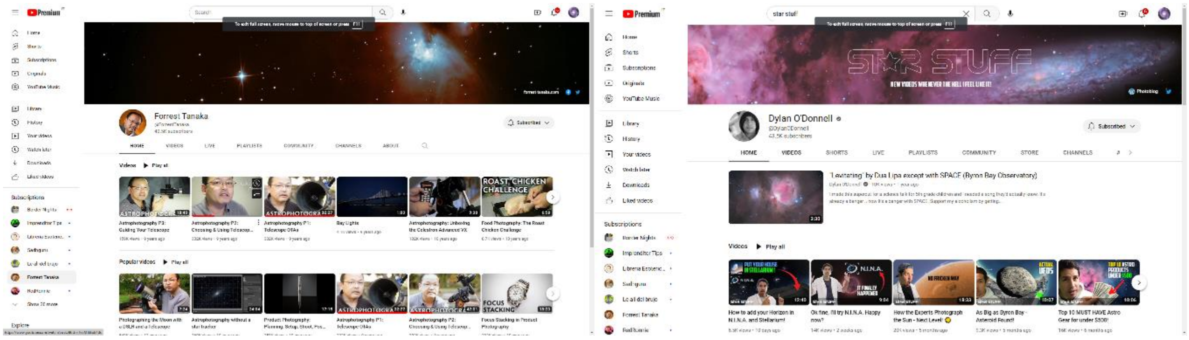

Figure 3: YouTube channels on astronomy by Forrest Tanaka and Dylan O'Donnell.

Astrophysics is closely related to astronomy and consists in the application of the methods of physics to space. It comprises areas such as the study of the *light and particles* arriving on Earth with the methods developed in *particle physics* laboratories, or the application of the laws of *gravitation and general relativity* to the motion of celestial objects and to the evolution of the Universe as a whole (*cosmology*), or even the application of *quantum physics* to the study of *black holes*.

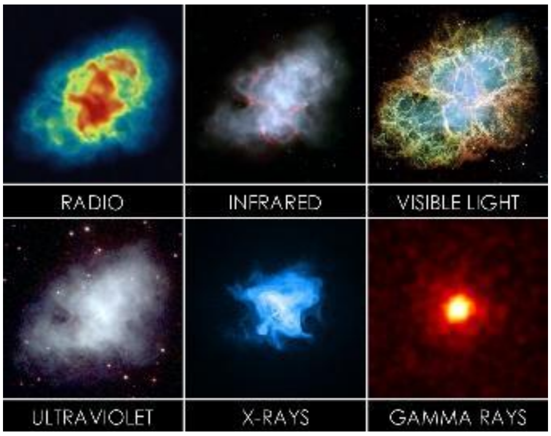

Figure 4: Images of a nebula taken in different ranges of the electromagnetic spectrum.

3.1.4 Telescope fundamentals

The king tool for any astronomer is the telescope. These simple yet amazing devices were invented in the Netherlands in the early 17th Century and were perfected over time by great astronomers and scientists such as Galileo Galilei, Johannes Kepler, Isaac Newton, Laurent Cassegrain. They evolved on one side into very large and complex devices used by professional astronomers, and on the other side into relatively simple devices accessible to the general public of sky and space enthusiasts.

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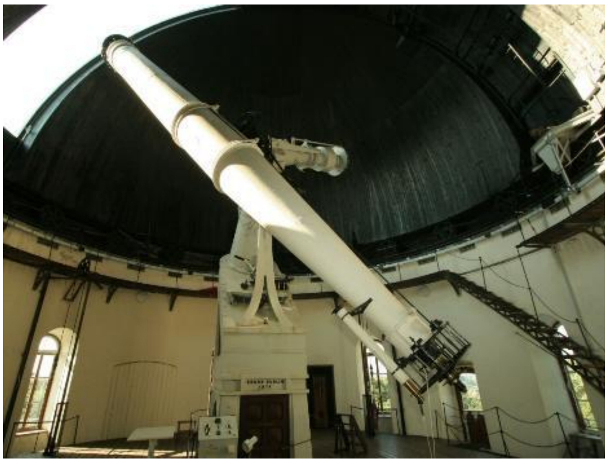

Figure 5: Refractor telescopes. The 68 cm refractor at the Vienna University Observatory

Figure 6: Refractor telescopes. An amateur refractor with alt-azimuth mount.

Whether it's a large telescope in a remote observatory, or an amateur telescope that one can use in the backyard, the basic working principles of every telescope are the same:

- a large main *light focusing device*, either a *lens* or a *mirror*.
- an *eyepiece*, to enable direct observation, or alternatively a *camera* to collect the image.
- a *focusing* mechanism, to adjust the telescope to the distance of the observed object.
- Optionally, additional optical elements to *enhance the power* of the telescope.
- A *mount* and a *tripod* or platform, to support the telescope and keep it aligned in the desired direction, and possibly to *track* the observed object with computerised motors.
- A *pointing* device (sight, accessory telescope, computerised system etc.), to aim the telescope in the desired direction.

Small amateur telescopes are built to work in the range of *visible light*, while large observatory telescopes can go beyond and collect images in the *infrared* and *ultraviolet* ranges of the electromagnetic spectrum. In addition, astronomers often use dedicated devices to collect "images" in frequency ranges far from the visible, such as *x-rays*, *gamma rays* and *radio*.

The basic properties of any telescope can be summarised in few key specifications:

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- **Focal length:** *a telescope's enlarging power* – The focal length of a telescope is the distance behind the telescope at which the rays of light, coming from an infinitely far object, are concentrated. It is directly proportional to the telescope's enlarging power.
- **Aperture**: *a telescope's light gathering power* – This is the physical aperture of the telescope: the larger the aperture, the larger is the amount of light that can be collected. With more light, a telescope can provide a brighter image, reveal dimmer objects in the sky and allow for astrophotography with shorter exposure times.
- **Relative aperture:** *a telescope's light flux measure* – It is the ratio between focal length and aperture; it measures the light flux that a telescope can deliver at the eyepiece or camera. It is very useful to compare different telescopes.

4 Types of telescopes

There are three types of telescopes which are broadly accessible to the public of enthusiasts and amateurs, excluding advanced dedicated equipment found in observatories. Each type has advantages and disadvantages, and no one is remarkably better or worse than another; rather, each can be more or less suited to a particular observational purpose.

Refractor (Keplerian) – This is the very first type of telescope invented. It comprises two optical elements: the front *converging optical element*, for main light gathering and concentration, and the *eyepiece*, for visual observation. While the very first devices employed the Galilean optical scheme, all refractors available today use the later Keplerian scheme instead. These telescopes are simple to build, quite affordable, usually light to carry, and offer great image quality for astrophotography, with ease of operation. They are however usually quite long, not very bright (medium to small

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relative aperture), and the simpler models can be prone to aberrations and colour fringes, although these are well corrected in the best models.

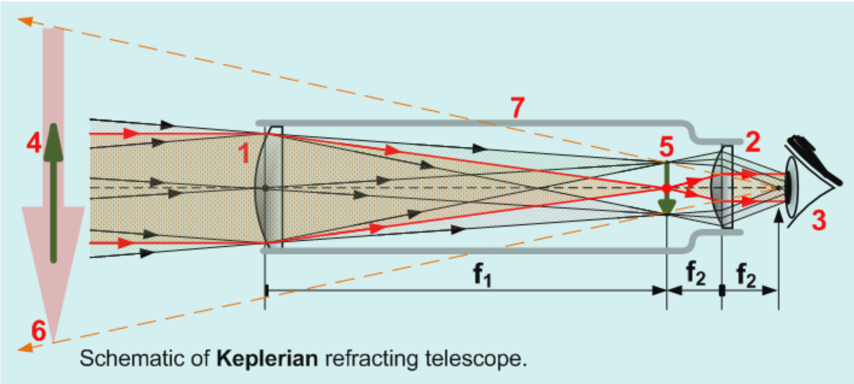
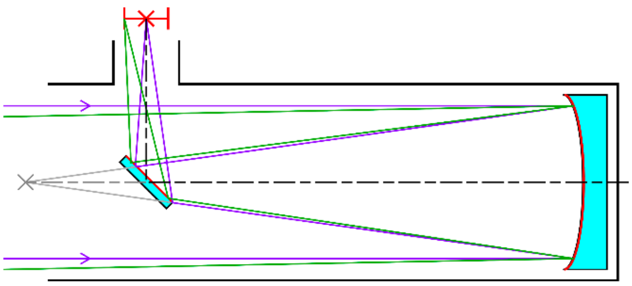


Figure 7: Keplerian refractor telescope. Optical scheme.

Figure 8: Portrait of Johannes Kepler.

Reflector (Newtonian) – The Newtonian reflector employs a *concave primary parabolic mirror* instead of a lens, together with an *eyepiece* for direct visual observation. Since the mirror is located at the bottom of the telescope, the eyepiece must be placed near the front opening; thus, a flat mirror positioned at a 45° angle needs to be placed inside the telescope near the main opening, to direct the light gathered by the main mirror towards the eyepiece. Reflectors too are also extremely popular among astronomers, because of many reasons: high quality for the price, easiness of manufacturing and building, high relative luminosity, and being free from chromatic aberrations. They are however relatively larger than comparable refractors, they don’t reach great powers usually (only short to medium focal lengths), and can be prone to coma if the mirror is spherical instead of parabolic, which is often the case because of cheaper and easier manufacturing.



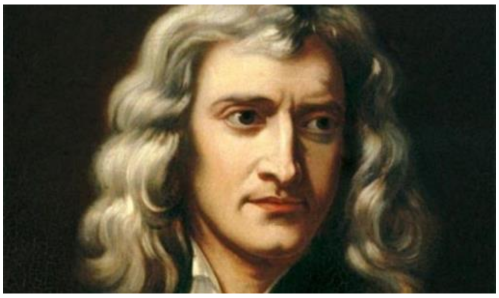


Figure 9: Newtonian reflector telescope. Optical scheme

Figure 10: Portrait of Isaac Newton.

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Besides, they are not so easy to use for astrophotography, requiring dedicated adaptations. These are minor limitations that can be circumvented quite easily, and Newtonians rightfully enjoy great success among astronomers.

Cassegrain and Catadioptric (Schmidt-Cassegrain, Maksutov-Cassegrain) – The Cassegrain telescope design and its variations constitute a modification of a Newtonian, to achieve *more enlarging power* (longer focal length). They do this by adding a *second convex hyperbolic mirror* in front of the primary concave parabolic mirror. A hole in the centre of the primary mirror allows the light to be directed to the eyepiece, behind the primary mirror. While the design is simple, the exact manufacturing of the curved mirrors can be difficult. Because of this, very often the primary and secondary mirrors are substituted by *spherical* mirrors, at the cost of introducing optical aberrations. These defects are then corrected with the *addition of a lens* in the optical path, leading to a so-called *catadioptric* design. The Schmidt-Cassegrain and the Maksutov-Cassegrain are the two most common optical designs implementing this solution. Catadioptric telescopes are very successful, because they are usually very compact and therefore portable, they can be very powerful, and they are as easy to use as a refractor for astrophotography. They usually have small to medium apertures and are comparatively more complex and expensive than refractors and reflectors. Still, they represent an excellent compromise, in fact most high-end amateur telescopes are of this type.

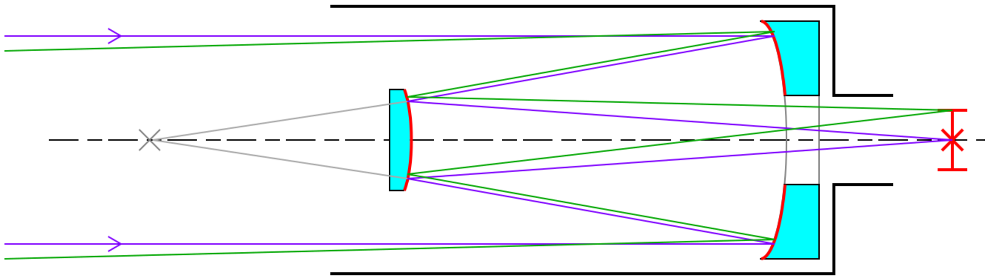

Figure 11: Optical scheme of a Cassegrain telescope.

4.1.1 Basics of photography

Astrophotography is a fundamental part of astronomy, being the basic technique for obtaining *direct proofs* and traces of astronomical observations. It is also an immensely rich field of *creative photography*, providing a broad spectrum of subjects and opportunities for creating beautiful images: from broad views of the Milky Way on

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a clear and dark night, to pictures of planets in the solar systems and the Sun itself, to views of nebulas and other galaxies.

Photography has become increasingly popular and easier thanks to the technological advantages of the last few decades: from electronic exposure automation, to autofocus, to the direct feedback and cost cutting benefits of digital cameras, up to extreme portability, good quality and ease of sharing of today's smartphone cameras. While many types and genres of photography have become easier and more accessible, astrophotography is still one of the most technically demanding areas of photography; therefore, to get started in astrophotography one needs to grasp the basics of photography itself.

Photography can be intended both as a *tool, a technique* for creating 2-dimensional images through a mechanical, a chemical or electronic process, and as a *visual language*. It is a practice, a means of creating images, independently of their use or purpose. Photography is often used for a variety of destinations and intentions: documentation, evidence, news, artistic expression, persuasion (advertisement) etc…

The technical aspect and the communication, visual and aesthetic aspect are complementary and both important for the creation of a successful photograph. A discussion on what makes an effective photograph from the visual and communication point of view is beyond the scope of this magazine, so from now on we will focus on the technical aspects of photography.

4.1.2 Basics of camera components and operations

In the following, we will review some key concepts of photography. From our 3-dimensional dynamic world, light is collected and focused by a camera's *lens*, and projected onto some surface holding a *light-sensitive medium*: a piece of *film* or a *digital sensor*. A camera usually allows us to choose *how much light* comes to the sensitive medium, and for *how long*. The result is a *static image,* which can be recorded, stored, printed, copied, transmitted.

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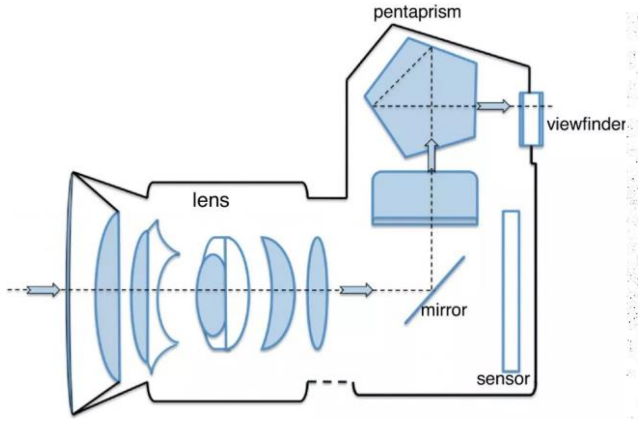

Figure 12: Single Lens Reflex camera. Schematic design.

Figure 13: Example of a film single lens reflex from the late 1970s

The *essential components* of any camera are:

- **Light-tight box:** it creates the *dark environment* where the sensor/film is exposed to light.
- **Lens:** it *creates the image* – It focuses the light to the focal plane on the sensor/film.
- **Recording medium:** light-sensitive material, either *film* or a *digital sensor* + memory card.
- **Viewfinder:** it allows the photographer to *pre-visualize* and *compose* the image.

Even though there exists a great variety of camera types, some *essential controls* are always present:

- **Lens Focus:** to be set according to the *subject/camera distance*, to deliver the sharpest image.
- **Lens aperture:** it is the *wideness of the hole* through which light passes. It is controlled with a device called **diaphragm,** just like the *iris of our eye* changes the wideness of our *pupil.*
- **Shutter speed:** it is the *duration* during which the film/sensor is *exposed to light.* This is achieved through a mechanical or electronic device called *shutter.*

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- **ISO sensitivity**: it is a measure of the *responsiveness to light* of the film/sensor. For film photography, it is a fixed property of the film. In digital photography, the light reaching the sensor generates an analogue electronic signal, which can *be electronically amplified*. The ISO sensitivity controls the magnitude of this amplification.

Figure 14: Basic camera controls: focus, aperture, and shutter time.

Lens aperture, shutter speed and ISO sensitivity together constitute the three **exposure controls,** allowing us to adjust the camera according to *the huge variety of light levels* of the world outside. In fact, we need to make sure that just the *optimum amount of light* reaches the film/sensor for the best image capture, so that the image is neither too dark nor too bright.

A wealth of material about the basics of photography is available online, and we recommend:

- Free eBooks on Photzy.com - resources for photography training, from getting started to advanced techniques in many.
- free guides on photography basics by Dan Zafra.
- free tutorials by Phil Steele.
- course by Phil Steele on camera fundamentals.

Figure 15: Online resources on the fundamentals of photography: photzy.com, capturetheatlas.com by Dan Zafra, and steeletraining.com by Phil Steele.

4.2 Practical approach

In this training we gave a prominent role to *practical activities*, believing that these sessions can facilitate *learning by doing and by experience*, while encouraging *collaboration* among students, development of *team-play* skills, *social and emotional intelligence*. Therefore, we lead the students through various practical sessions, as detailed in the following.

4.2.1 Assembling a telescope

For conducting a successful astronomical observation session, one needs to gain sufficient mastery and knowledge of the basic operations and parts of a telescope. With this in sight, the students *assembled a telescope starting from its basic components*, so that they could observe, test, and understand each element, its function and how to operate it. It is essential that this preliminary activity is carried out during the day, with plenty of light and no rush, so that sufficient familiarity with the device is gained. This way, one can later find himself or herself at home also during the night observation sessions.

4.2.2 Usage of telescope: polar alignment and observation

Figure 16: Astronomy and astrophotography session near Nevşehir, Turkey.

After the preparation, we were ready for a real astronomy session at night. In this experience, the students brought the telescope to a chosen *outdoor observation site*, far enough from the city centre to reduce the effects of *light pollution*. First, they had to *reassemble* the telescope at the site, then *test* that all the fundamental operations work as intended (pointing, movements, collimation of sight).

The next step is the crucial *polar alignment*, which is possible if the telescope is supported by an *equatorial mount*. To learn more we recommend the video by Forrest Tanaka, but in short, polar alignment consists in *aligning one of the rotation axes for pointing the telescope, with the Earth's own rotation axes*. In practice, this can be done precisely by *pointing the telescope to Polaris* with the equatorial mount movements, then setting this position as the *base position* for further pointing of other sky objects. Thanks to this, the movement of celestial objects across the sky due to the *Earth's own rotation* is easily compensated by operating just one movement on the telescope, the so-called *Right Ascension.* The other movement required for pointing an object in the sky is called *Declination*. If the mount is motorised, *automatic tracking* of celestial bodies becomes possible.

Figure 17: Astronomy and astrophotography session near Nevşehir, Turkey.

In case this precise alignment is not possible because Polaris is not visible, a more approximate alignment can be done by setting the *azimuth* control of the equatorial mount towards *North* with the aid of a compass, and the *altitude* control of the mount at a degree corresponding to the *latitude* of the site of observation. The polar alignment done in this way is never accurate enough for astrophotography, non the less it allows for easy tracking of celestial objects for visual astronomy.

Once polar alignment is achieved, we are ready for the observation of any object in the sky. In case the telescope has a simple manually controlled mount (not a computerised one), one can point the telescope to any visible object in the sky. This is quite easy with the aid of a *sight* or *finderscope,* usually included with every telescope. A variety of objects is observable with this procedure, including the nearest planets of the Solar system, the Moon and many near stars.

4.2.3 Usage of camera at night

Astronomical photography is usually carried out *with telescopes* or *long telephoto lenses*. There are however many possibilities that one can explore even with a *normal camera and lens*, such as *star constellations*, *night landscapes* including the night sky, and especially the wonderful *Milky Way*.

Milky Way photography is quite different from any other type of astronomical photography. The galaxy we live in, when visible, *spans across the whole sky*, therefore it is best photographed with *wide or ultrawide lenses*.

While modern digital cameras can easily take care of the technical burden in a lot of photographic situations, unfortunately for astrophotography this is not the case. It is in fact a rather technical application of photography, where automatic systems can't do much. Therefore, one needs a good grasp of a few key technical aspects and settings.

The first step towards astrophotography with a normal camera (especially of the Milky Way), is gaining familiarity with the basics of night photography:

- Operating the camera on a *tripod*
- Firing the camera with a *remote trigger* (cable or radio), or with self-timer
- *Measuring and setting exposure manually*
- *Setting the focus manually*
- Setting the camera's *image digital controls* (ISO, sharpness, contrast etc.) for the best quality

While all these operations and controls are usually straightforward, performing them at night, in the dark and with limited time available due to changing environment conditions, can be challenging.

4.2.4 Photography of the Milky Way with a normal camera

Astrophotography of the Milky Way requires particular care. Fortunately, one can find many good resources online devoted to this, such as the tutorial by Jenn Mishra for getting started with astrophotography, or many articles by Dan Zafra on Milky Way photography.

Figure 18: The Milky Way; picture taken during the training.

The *preparation* is of paramount importance, starting with the very *choice of site and timing*. We will go into this in the next section.

When on the field, the first technical challenge is setting the *focus* correctly on the far stars in the sky. This needs to be done *manually*, for example pointing at one of the brightest stars, a planet, or a light on earth very far away. Once done properly, focussing can be left alone for the rest of the session.

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The second crucial technical aspect *is setting the exposure controls* (ISO, aperture, shutter speed) for the best possible image with the equipment available. The Milky Way is very dim, so it requires a very *long exposure time* with a *wide aperture* and somewhat *high ISO*. However, if using a conventional camera tripod*, one cannot use too long a time*, otherwise the Earth motion will cause the stars to form *trails*, that is, they will appear as lines instead of just points. Also, it is always best to *keep ISO as low as possible* to reduce electronic *noise* and preserve image quality. Furthermore, most lenses can show *coma* (a type of optical aberration) when used wide open, therefore one should *close the diaphragm a bit* for the best results. A good strategy can be the following:

1. Set the *lens aperture wide open* (or at most closed by 1 stop to reduce coma).
2. Set the *shutter speed as long as possible*, but not too long as to form *star trails*. This will require some trial and error, but a thumb rule is that if one is using a lens of focal length *f,* the best exposure time is around 400/*f.* For example, with a 20 mm lens, the maximum time is around 20 seconds.
3. Set the *ISO as high as needed* to have a bright enough image. Typical values can be around 3200 to 12800. Bear in mind that since this is a night photo, one or two stops of underexposure compared to usual is acceptable.

4.2.5 Astrophotography with a telescope: smartphone, conventional camera, dedicated telescope camera

Astrophotography with a telescope can be challenging, but the results always reward all the effort.

There are two main difficulties:

- One needs a *motorised equatorial mount* and to perform *a very good polar alignment.*
- *Exposure times can be very long*, with all the implied challenges.

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Figure 19: Astrophotography with a telescope. Jupiter and three of its satellites.

Figure 20: Astrophotography with a telescope. The Moon

There are various ways for taking a picture of the image created by a telescope:

1. The simplest and easiest way is to attach a *smartphone* on the telescope *behind the eyepiece*, to capture the image coming right through it. The quality level can vary a lot, but it is a good first step. One needs a way to trigger the phone camera remotely.
2. A much better solution, even though still a compromise, is attaching a *digital camera* to the telescope, either a digital reflex or a mirrorless camera. This is easily done with a dedicated *adapter*. It is usually straightforward with refractors and Cassegrain-like telescopes, while it can be trickier, but still feasible with Newtonians, because of some inherent technical features of Newtonians, that make focusing more complicated and need special care. This approach is a very good compromise between image quality and practicality, especially if one already has a camera available. Once connecting the camera and focusing are sorted out and provided the telescope is capable of good tracking, photography is straightforward and very similar to any other night photography situation.
3. Using a *dedicated telescope camera*. This is the best option, allowing for exploiting the telescope to its full extent and obtaining the best possible images. There are a great variety of astronomical cameras, suited for different purposes, but even an entry level one is a step up compared to using a normal camera. A practical limitation is that all these dedicated cameras usually work connected to a computer; this may not be an issue if operating near a building, but it can be challenging if one goes to some remote location.

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4.3 Astrophotography: planning and preparation

Conducting a successful astronomy or astrophotography session requires some *simple but fundamental planning* in advance. In fact, we are challenging ourselves in observing and capturing *natural objects and phenomena*, be it the Moon and its phases, a planet, or the Milky Way, so we need to be aware of their motion and evolution in the sky, and of the natural conditions of the location from where we wish to carry out the observation.

The first step is of course deciding *what* we wish to observe, that is, which celestial object we are interested in. Then, we need to do some research about *when* the celestial object is visible from *where* we plan to perform the observation. Luckily, there is plenty of information available and accessible online, in the form of calendar tables, or even more easily in dedicated apps, such as Star Chart, Photopills or The Photographer's Ephemeris, or Moon Phases, specifically dedicated to the Moon.

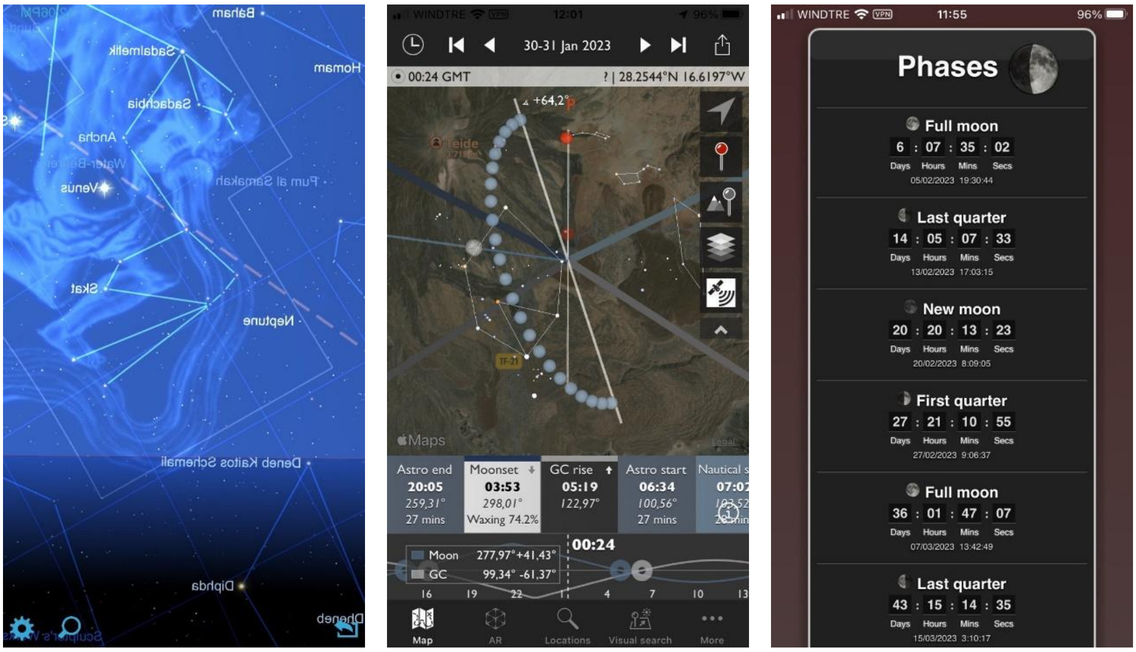

Figure 21: Applications for astrophotography planning: Star Chart, The Photographer's Ephemeris and Moon Phases.

Special care needs to be put on the choice of the *observation point*, for two reasons: first, the same object may be visible in *different periods of the year*, or at *different times of the day*, from different locations; second, we need to ensure that at the observation site *light pollution* is sufficiently low. Many online resources are dedicated specifically to this, for example Dark Site Finder.

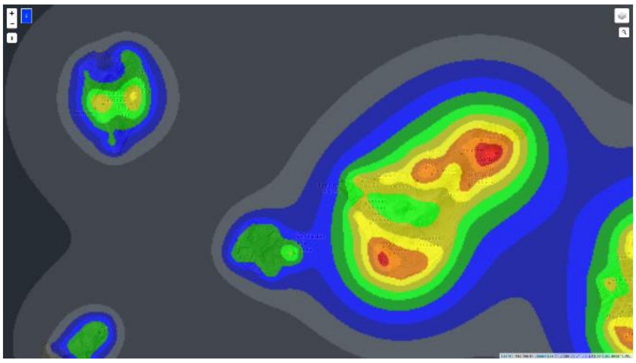

Figure 22: Example of light pollution map from darksitefinder.com.

Next, depending on our choice of celestial object to observe, we need to select the best equipment in our reach that will allow us to observe and capture it. Or, much more practically, we will do our best with what we have. In any case, we need to gain as much familiarity and mastery with our equipment as possible, before and during the observation session, for achieving a satisfying observation. Bear in mind, however, that a photographic capture may be more challenging and time consuming than a simple visual observation. In any case, we need to choose and *prepare* the equipment we will use carefully, plan the *transport* to the chosen observation location, in case a trip is involved, and factor in the time required to reach the location and *set up* the equipment.

Finally, the last thing to check carefully is… the *weather*! Even though this may sound obvious, this is as important as the previous points in the preparation of an observation.

4.4 Photo Editing and Processing

It is easy to think that once an observation and astrophotography session is concluded successfully, we're done, and sometimes this is indeed the case. More often, however, digital capture is only one step in a larger process that continues and culminates with the *editing*, *processing* and *final image export* in the computer. For this reason, we included in our workshop various training sessions covering the basics of digital image editing and processing. A huge wealth of training material exists online, both on

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general photo processing and on techniques for astrophotography. Among others, Photzy.com offers both [free tutorials](#) and more [advanced training material](#).

Figure 23: Adobe Photoshop Lightroom Classic.

Once our photos land on the computer, the first step is always… *looking at them*! Thanks to digital capture, we can take as many pictures as we wish, but we rarely if ever need all of them, so the very first step is *choosing our best images*, so that later in post processing we can focus our efforts on them only. For a few pictures this can be done simply with our computers' finder/explorer program, but for larger numbers and better efficiency, many applications have been created specifically for this purpose. The most popular is by far *Adobe Lightroom*, for which a huge wealth of training material exists online, for example the [Lightroom course by Phil Steele](#).

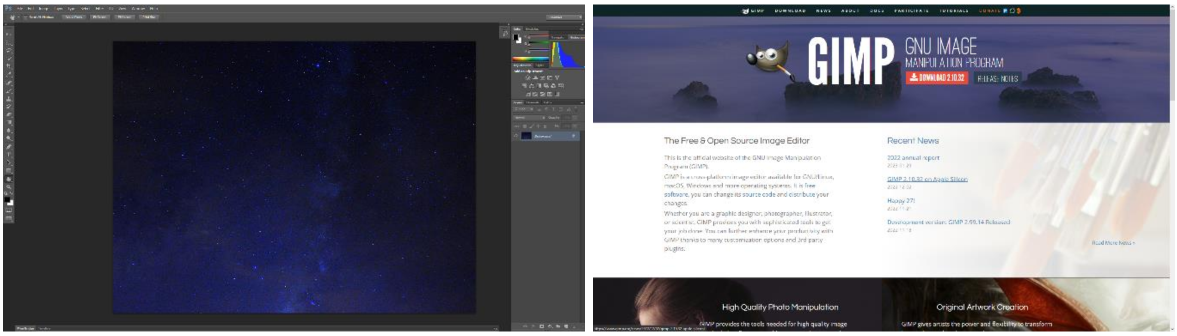

Figure 24: Photo processing software. Adobe Photoshop (left); GIMP (right)

The next step is the core processing of the selected pictures in some specialised software, the most known and industry standard being of course [Adobe Photoshop](#). Even though it is paid software, *discounts exist for schools and educational institutions*. [Phil Steele offers a course on Photoshop](#) too, and online one can find countless tutorials, articles and videos. One can also experiment with many free alternatives to Photoshop, among which the best and most complete is [GIMP](#).

Going into photo processing aspects which are more specific to astrophotography, we just mention here two techniques:

- *Noise reduction*: this step is all-important in astrophotography, since most likely the images are taken at medium to high ISO values. Lightroom, Photoshop and most photo processing applications have built-in tools for this, which usually perform a good job. However, for the best quality there are few applications dedicated to this task, such as Topaz DeNoise AI.
- *Stacking*: this operation consists in taking many pictures of the same subject, in sequence, and combining them together to get a final image with more detail and less noise than any of the individual initial images. This can be done in Photoshop with a bit of work, and dedicated applications exist specifically for this purpose, for example Sequator.

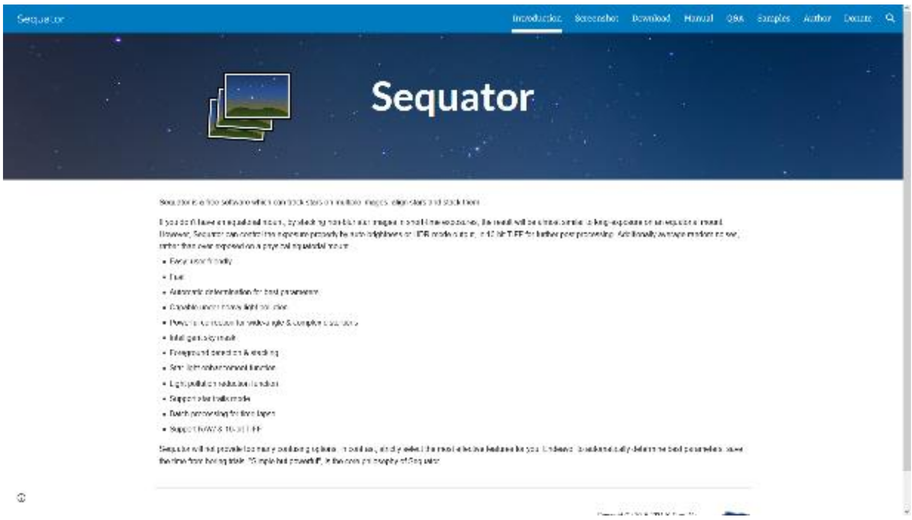

Figure 25: Sequator, an application for automatic stacking of astronomical images.

5 Mobility and Training Activities

5.1 Space and Astronomy Tenerife

5.1.1 IES Manuel Martín González and Erasmus+

The IES Manuel Martín González is an institute for Secondary Education, Baccalaureate and Vocational Training located in the municipality of Guía de Isora, in the southeast of the island of Tenerife. It is an area of the island that until relatively recently was isolated from the main urban centres since there was no fluid communication route to our municipality. This fact has meant that our students have had fewer options when it comes to moving around or carrying out activities outside the municipality.

Figure 26: Guía de Isora in Tenerife.

Figure 27: Students of Vocational Training during one of the training days.

That is why, in 2014, one of the Vocational Training teachers studied the possibility of participating in Erasmus+. At that time, Erasmus+ would put our IES, our municipality and all our students on the map. It would be established as a tool so that our students could expand their training to other countries and also so that companies could enjoy everything that our students have to offer. That is why, in the 2015-2016 school year, the first project of mobilities for Vocational Training for Higher Education (Higher Level Training Cycles) was approved. In it, the students of the Administration and Automotive professional families begin to carry out their Training in Work Centers through an internship period in countries such as Germany, the Netherlands, the United Kingdom, etc.

Given the success of the first mobility trainings, the management team of the

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center decided to give firm and continuous support to the internationalization project, Erasmus+ in high school and Baccalaureate level.

5.1.2 IES Manuel Martín González and the 'Space and Astronomy' Project

In this Erasmus+ expansion process, a proposal from one of our European partners arrives at our centre, inviting us to participate in a project on Astrophotography. Our centre is located in one of the parts of the world with the best conditions for space observation, so an Erasmus+ project in which we can teach the rest of the partners and participants what the sky looks like from this corner of the Atlantic seems very interesting to us.

Figure 28: Students during a lesson with the astrophysicist, Dr. Marco Pezzutto.

It is decided to participate in the project and carry out the mobility to Turkey and Brussels with the selected students, as well as hosting our partners in Tenerife. In the two mobilities you travel with 4-5 students and 2-3 teachers. In Turkey, observation and photography training sessions are held. In Belgium there are training sessions on photo editing. In both mobility trainings, teachers and students made a very positive assessment. It is a theme that in most cases is somewhat unknown, even coming from one of the most suitable places for its realisation.

5.1.3 Activities of the training week in Tenerife with the 'Space and Astronomy' project

Figure 30: Lessons at the school.

The training of the "Space and Astronomy" project in Tenerife is presented as an opportunity for all our partners. It is an astronomical observation and photography project in one of the most privileged places in the world for it. Hence, we took this opportunity to invite our students and guests to visit the astrophysics and observatory centre of Tenerife. Hence from our educational centre it is decided to give all possible relevance to the environment with all that this entails, that is, the week is planned with the intention that all participants enjoy night observation of the reference institutions at a national level that are found on our island and of all the culture related to the world of astronomy and astrophysics. All partners from Belgium and Turkey participated in this training. The physicist who was in charge of training, Marco Pezzutto, and the project designer/coordinator, Elnaz Shadras, attended from Belgium. Two teachers and a group of four students attend from Turkey. All the students who have made the previous mobilities within the Space & Astronomy project participated from our school, the director Sergio Hernando, the Erasmus coordinators Manuel Hita and Elena Morales.

The week began with a training session at the centre where we introduced ourselves and made a first approach to the use of the telescope. Once the training session was over, we made our first night observation at the Mirador de Los Poleos, a unique area that, in addition to having very good conditions for astronomical observation, allows us to see the islands of La Gomera, La Palma and El Hierro. In addition to astronomical photography, light painting activities were carried out, obtaining truly amazing results.

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Figure 31: Light Painting.

The second day of the mobility training was perhaps the most surprising in terms of work done. Firstly, there was a training and sharing at the school, given by Marco Pezzutto, and then we moved to Las Cañadas del Teide, an area located within the Teide National Park, an ancient volcano that it is located at more than 3000 metres of altitude and where there is also very low light pollution. In addition to the impressive observation of this day, the place is unique for its volcanic characteristics and its wild landscape. On this day we were able to observe the rings of Saturn and planet Jupiter, and we were able to take several photographs of the Milky way that would be shared as the results of our astrophotography gallery.

The next day, we left the routine of night visits to go on a guided visit to the Instituto Astrofísico de Canarias, a world reference institution in Astrophysics. The visit was guided by one of the technicians, they told us about their history, their ongoing projects and they let us see their amazing facilities. In addition, once the visit to the headquarters, located in San Cristóbal de La Laguna, was over, we were able to access the telescopes located in Izaña, at an altitude of more than 2,500 metres, through a guided tour by one of its researchers. During the visit to the telescopes, we were able to carry out solar observation through a specific telescope for this purpose; the penultimate day of the training mobility, the city of San Cristóbal de La Laguna was visited again and two different activities were carried out there. First, the Museum of Sciences and the Cosmos was visited, which is one of the most didactic spaces in this

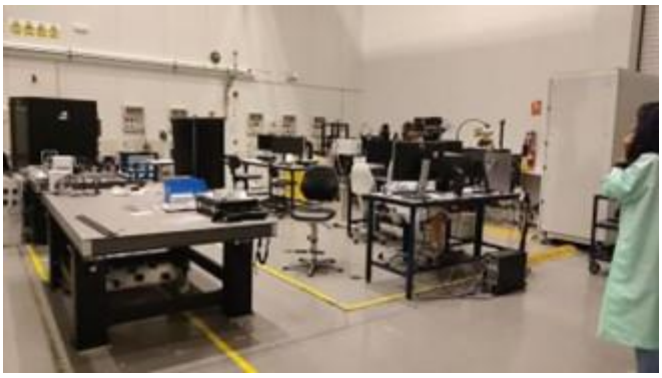

Figure 32: Visit to IAC headquarters.

branch that our archipelago has and a guided route through the historic centre of La Laguna, a World Heritage City, declared by UNESCO more than 20 years ago.

Finally, we closed the mobility week by sharing all the work done in our educational centre and with a small act of awarding certifications.

Figure 33: Visit to the central of La Laguna (left). Interior of the museum (right).

5.1.4 Implementation of the results in our school

After the Space and Astronomy project we have realised that the place where we live is a privileged area for the study of the sun, the stars and the universe. So, from now on, we are going to implement the same activities to all the levels of the high school. We are going to organise an observation activity each month in the surroundings, for doing the observation we have thought to get a telescope and to join our school to a working group that actually exists in our teachers' centre.

5.1.5 Photo Exhibition

The photo exhibition has been carried out in our main building, specifically in our assembly hall. The photos taken during the mobility trainings in Turkey and Tenerife, and then retouched in Brussels, were exposed during a week. Here, all the teachers from our school could see the amazing results of our work. We organized the secondary groups to visit the exhibition during the week, and all of them could know about the Space and Astronomy project. The students who participated in the trainings were the project ambassadors, and they oversaw explaining all the objectives and experiences they had. We realized that the project has helped students shaping a batter point of view about Europe, about Tenerife in Europe and about the diversity of European cultures.

All the teachers and the education community also visited the exhibition and gave very positive feedback. The exhibition has been a perfect tool to show our activities within the Erasmus+ projects and we are confident that teachers will include some of the project activities in their daily class work.

Figure 34 Photo Exhibition at IES Manuel Martín González

5.1.6 Dissemination and Sharing

We have used several ways for the dissemination of the project. First, we have created in our website a page for the Space and Astronomy project in which we explain all the mobilities and activities we have done. You can see it in this link:

https://www3.gobiernodecanarias.org/medusa/edublog/iesmanuelmartingonzalez/space-astronomy-erasmus-project/

We have used the Instagram social media and we have created a page only for the project in which we have uploaded some of the best activities we have made:

https://instagram.com/spaceastronomyiesmmg?igshid=ZDdkNTZiNTM=

In addition, we have shared in our official Instagram and Facebook pages some of the activities that have been carried out.

5.1.7 Conclusion of IES

Our institute has received very good feedback on all the mobility trainings carried out by all our participants. We can assure you that it was a very successful week with a diversity of activities. Our students also got to know an aspect of their closest environment that they were unaware of, likewise, part of the participating teachers has also recognised that it has been a unique mobility and with many aspects that can continue to be developed in the future.

Figure 35: Our lab visit at the Astrophysics Centre of Tenerife

5.2 Nene Hatun Mesleki ve Teknik Anadolu Lisesi (VET High School), Nevşehir, Turkey


Figure 36: Nene Hatun MTAL – School

Since the academic year 1945-1946, our school has been providing education under the name of Nene Hatun Vocational and Technical Anatolian High School. Our school is located in the city centre and is one of the largest and most equipped schools in our city. There are 42 teachers and 670 female students in our school. Our school is entirely geared towards the education of female students.

The educational approach of our school is constructivist and project-based, with students at the centre. The main aim of the school is to provide our students with a high-quality general education so that they acquire the key competencies and personal skills needed to become competent European Citizens.

Figure 37: Students at the school

Our school encourages the creation of a variety of learning approaches and contexts to introduce students of all levels to today's highly technological world by giving them the necessary skills.

A group of Science and Technology teachers at our school has chosen CODING as a teaching method to increase students' interest in these topics, encourage students to think more broadly about real-world problems and offer creative and personal

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solutions. With the approval of the Ministry of National Education, it provides robotic coding training to other school students and teachers in the city.

It is the only school with a 3D technologies certificate. Our school is willing and open to cooperation with other schools from different countries to exchange experiences and further develop and improve the knowledge of ICT teachers. development of information technology in the fields of engineering and programming, robotics, and artificial intelligence. This is the mission of our school. The school is included in a regional network created by Innovative Schools using Instructional Technologies (CITE) and offers two different scientific and technological projects depending on the age of the students. We know very well that individuals who have learned to learn at school will make a difference in the future.

Figure 38: Nevşehir LTT, Turkey

Creativity, critical thinking, communication, and cooperation skills need to be developed for a qualified and successful life in the 21st century. English teaching programs at our school are prepared by the principles of the "Communicative Approach". Digital learning platforms integrate the foreign language into the lives of students without the limitation of time and place.

Interactive digital learning platforms enriched with artificial intelligence technologies, which are blended learning tools, are used efficiently in foreign language teaching at our school.

5.2.1 Project Implementation by our school after the training

Within the framework of the restructuring of secondary education; a weekly lesson considering scientific and technical developments in parallel with the schedules of society, curricula are gradually renewed, considering the expectations of what has been started. In this context, developments in educational sciences are being prepared while curricula are being prepared. In cooperation with universities, the constructivist learning approach, multiple intelligence theory, lifelong learning, versatile thinking strategies, critical thinking concepts, and approaches that adopt student-centred learning theories are considered. In this context, Astronomy and Space Sciences Course, which is taught as an elective course, the program was reorganized in line with the developments in astronomy and educational sciences. prepared and made functional, especially at high school levels.

However, the program applied in our school; Instead of presenting the achievements directly to the student during the course, in a way that allows the student to fit them into a certain scheme in his mind. The studies were supported with this EU project, as a more constructivist approach was needed because the student could not observe and research through out-of-school activities, the course hours were insufficient, and the teacher was not a field expert.

Changing the understanding of learning and teaching all over the world, education from science and technology benefiting from the system at the highest level, putting the learner in the centre, and avoiding passivity. saving, considering individual differences, and living the learned Constructivist education approach has been adopted in our project and this approach has been applied at a high level in Nevşehir mobility.

During the Nevşehir mobility training, the students gained skills of various types: cognitive, affective, and psychomotor skills.

Cognitive Skills: critical thinking, creative thinking, problem-solving, analytical thinking, being able to think in three dimensions, using information technologies, entrepreneurship, reasoning, and communication.

Affective Skills: self-confidence, enjoyment of research, willingness to prepare a project, recognizing your talents and interests, developing responsibility, being patient, and self-questioning.

Psychomotor Skills: being able to use tools related to events, making mock-ups and models, being able to introduce and presenting the model or model, ability to experiment using laboratory tools.



Figure 39:Telescope and its setup

5.2.2 Nevşehir LTT First Training

The following subjects and activities were covered during the training week:

- Celestial objects – Mechanics of the Solar System
- Intro to Photography – Theory and Practice
- Intro to Astronomy observations – History of Astronomy
- Basics of the digital camera (engineering of the camera)
- Practical training with the camera: Site seeing & practicing the use of the camera (photography) 6th Practical Practice of Moon Photography **(Love Valley Ürgüp Nevşehir)**
- Discussion about yesterday's training and photography results
- Theory of Gravity and relativity
- Design and engineering of telescopes – Tech. of planet photography
- Completion of the training day
- Practical Training: Practice of star and planet photography (quality based on equipment) **(King Vadisi - Ürgüp Nevşehir)**
- Reviewing yesterday's photography work
- Training: Gravitational Redshift and gravitational waves
- Training: Planning for astrophotography – Milky way photography
- Site-seeing & practicing the use of the camera (photography)
- Practical Training: Practice milky way photography.

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Figure 40: Photography training

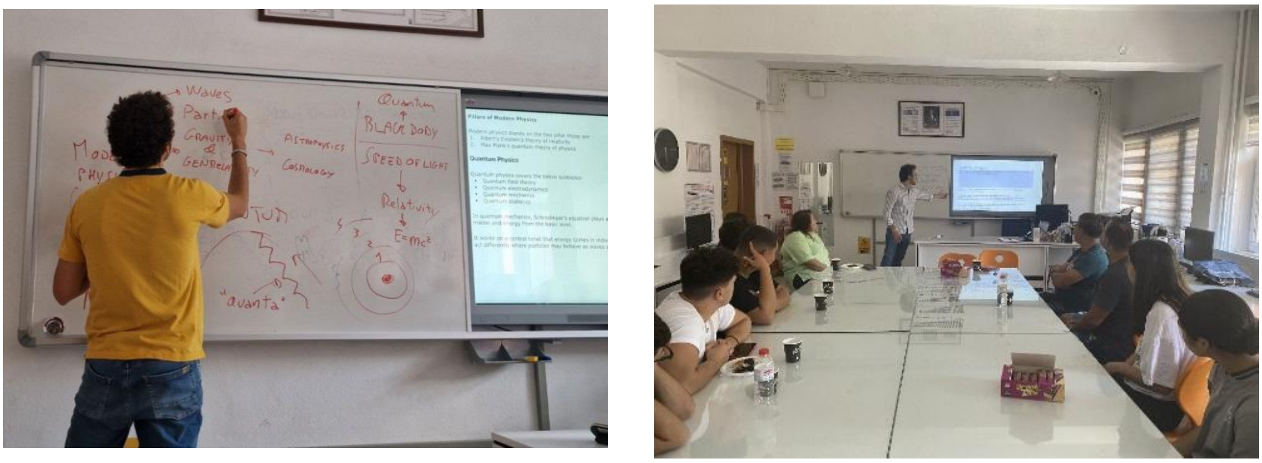

Figure 41: Mechanics of the Solar System training

Figure 42: Astronomy observations and intro to astrophotography

5.2.3 Implementation by our school after the training

The astronomy and space sciences course is an elective course and it is two hours a week in the form of processing; After the Nevşehir mobility training of our project, a student club related to the course was formed. After the education in Nevşehir, the concepts of scientific thought are taught more clearly to the students. The scientific importance of observation and experiment is taught, and within the possibilities, the Physics or Astronomy and Space Sciences Departments of the surrounding universities in cooperation with the university, students are provided to meet the faculty members working in these departments, are provided with information about their work. In the activities, appropriate visual, audio, and printed materials that can help gains materials are used as much as possible. In particular, a sky atlas of students' necessary work is being done to obtain them. Responsible for teaching the course teachers are given in-service training. To carry out in-class associations more healthily while the subjects are being covered, especially started to work in cooperation with mathematics and physics teachers.

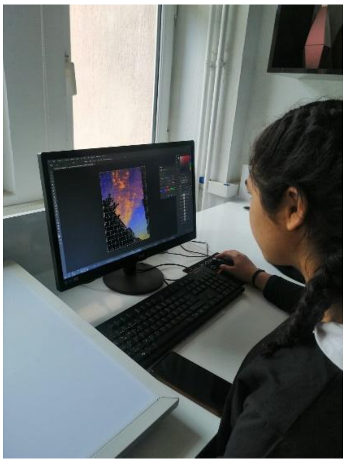
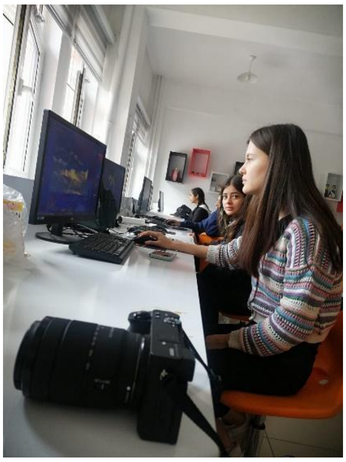


Figure 43: Learning professional Photo editing

5.2.4 Our advice for other schools in using this methodology

After the education is realized thanks to our project in Nevşehir, we can make the following recommendations to other schools:

- They can raise awareness of their students and parents against the science of astronomy.
- They can create a sense of curiosity by using scientific methods.

- They can apply their skills to astronomical events by integrating theoretical concepts and problem-solving, especially in mathematics and physics.
- They can teach the historical development of the science of astronomy, which is the oldest of the basic sciences, which will be given to the students.
- They can teach how to interact with rapid technological developments in astronomy and how they relate to basic sciences.
- They can teach basic observation tools used in astronomy.
- They can teach the development of space studies and their effects on our lives with a constructivist approach.

5.2.5 Websites used for sustainability of training material

Planning by taking into account the next week's activities when planning activities to ensure sustainability, is important for the preparation of teachers and students. In a free and democratic environment, especially in classroom discussions, we attach importance to the ability of each student to express their thoughts. To ensure scientific language unity, teachers and students pay attention to learning the terms and concepts of space sciences correctly; for this purpose, we use the "Astronomy Glossary". There are many Internet sites related to astronomy and space sciences. Some of these sites publish pictures taken by amateur astronomers. We are constantly sharing these websites for sustainability.

1. http://www.aerospaceed.org
2. http://astro.unl.edu/
3. http://www.astrosociety.org/education.html
4. http://www.astrosociety.org/education/publications/tnl/14/14.html
5. http://www.astrosociety.org/education/publications/tnl/51/astrobiology1.html
6. http://nssdc.gsfc.nasa.gov/
7. http://nssdc.gsfc.nasa.gov/photo_gallery/
8. http://www.nasa.gov/audience/foreducators/index.html
9. http://www.atmturk.org/index.php/Main_Page
10. http://www.tug.tubitak.gov.tr/
11. http://astronomy.ege.edu.tr
12. http://astronomy.science.ankara.edu.tr/

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13. http://rasathane.ankara.edu.tr/
14. http://www.istanbul.edu.tr/fen/astronomy/
15. http://physics.comu.edu.tr/caam/caam.html
16. http://www.koeri.boun.edu.tr/astronomy/astronomy.html

5.2.6 Space and Astronomy Project Photo Exhibition

In the framework of the Space and Astronomy Project, we organized the school photography exhibition, with photographs by our students, and invited all teachers, students, education administrators, and staff from our school and other schools in our province, as well as their family members.

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5.2.7 Dissemination and sharing

- https://www.instagram.com/p/CkbcFAKr4ji/?igshid=MDJmNzVkMjY=
- https://nevsehirktml.meb.k12.tr/icerikler/2-projesi-olan-space-astronomy-isimli-projesinin-ilk-toplantisi-gerceklestirildi_13531779.html
- https://nevsehirktml.meb.k12.tr/icerikler/ogrencilerimiz-ispanyada_13375784.html
- https://www.lalehaber.com/nevsehirli-ogrenciler-ispanyada-51956-haberi
- https://www.facebook.com/groups/435864232020859/permalink/489747086632573/

5.2.8 Photo exhibition of the Space and Astronomy project on social media

- https://www.facebook.com/groups/435864232020859/permalink/498610562412892/
- https://www.facebook.com/677182725/videos/4355722744566433/

Nene Hatun Mesleki ve Teknik Anadolu Lisesi: https://n evsehirktml.meb.k12.tr/

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5.3 Third training at Voices of the World in Brussels

After our exciting travels to Nevsehir and Tenerife with our students, and taking pictures in the valleys of Cappadocia and on the tips of Mount Teide, we continued with the learning of photography and the use of telescopes in astrophotography. During our training week, we learned more about Astronomy and how observatories use their telescopes to take amazing pictures from galaxies and even the black hole. We studied how the colourful pictures shared by NASA are in fact improved by modern photo editing tools, for people to be able to capture the real essence of space.

Dedicating to our goal of astrophotography, we focused on how to use modern photo editing tools as well, in order to improve the photos we took of the stars. We closed the week with a beautiful photo exhibition of the edited astrophotography done by the students and teachers who participated in the trainings.

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Figure 44: Learning photo editing

Figure 45: Preparing for photo gallery

Figure 46: Vernissage of the photo gallery

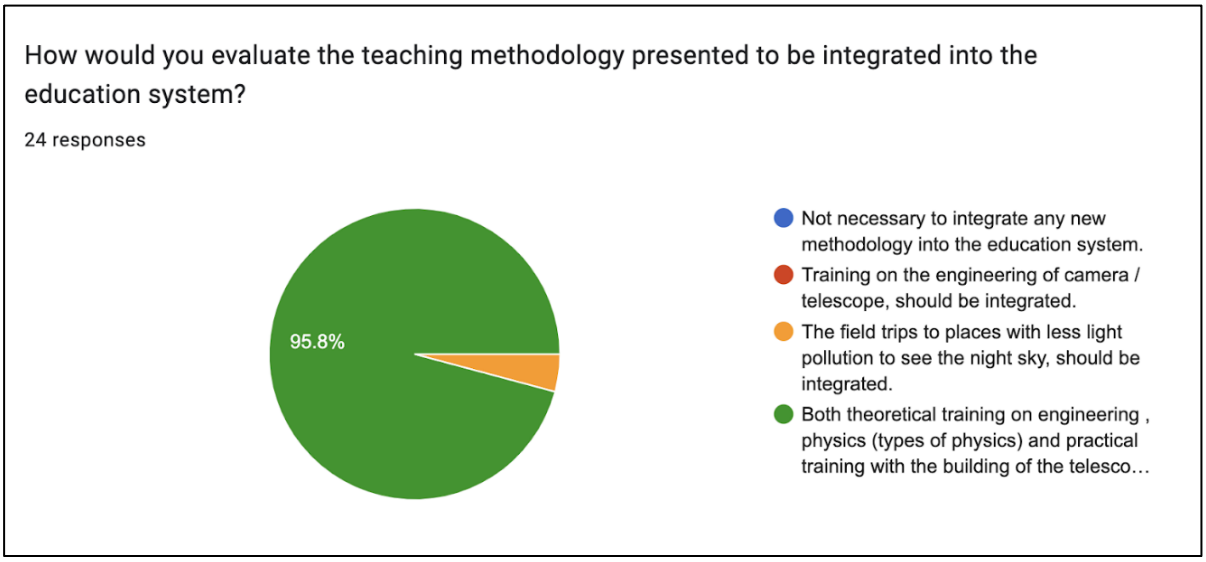
6 Quantitative and Qualitative survey with project participants to measure the impact of the teaching methodology suggested in our training and publication

We conducted a survey, after requesting teachers and students who participated with their students and peers to evaluate and collect data on how students reacted to the new interactive methods introduced after briefly executing the methodology in their consecutive classrooms. This study was to assess the immediate impact of Space & Astronomy teaching methodology evaluating whether it motivates students to be more involved and curious about STEM subjects, as well as whether such activity encourages them to pursue studies in science and/or digital art.

The data was collected from 24 students and teachers who participated in the implementation of the project provided by Voices of the World.

The survey results were to measure the impact of this teaching methodology, whether it's possible to add the school curriculum and how best is it to keep the methodology sustainable.

6.1 Quantitative Results



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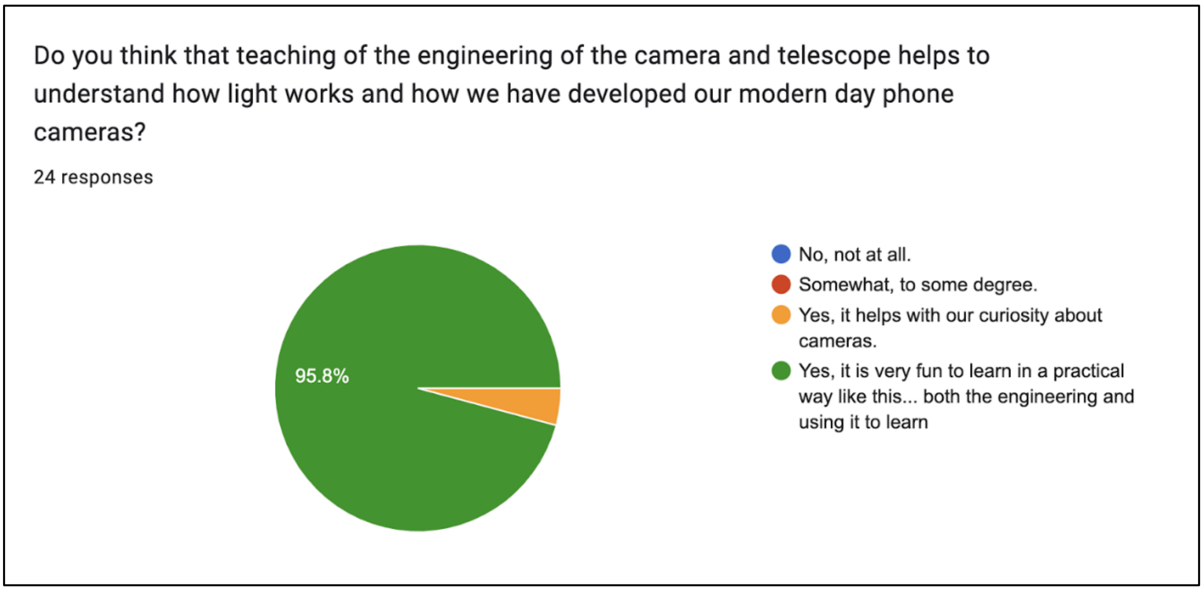

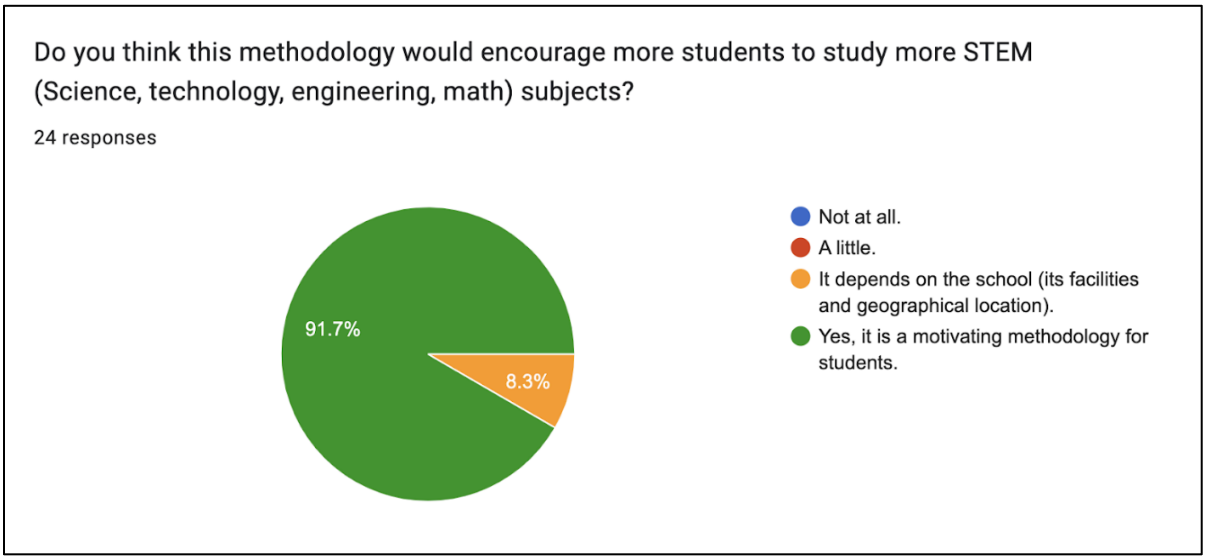

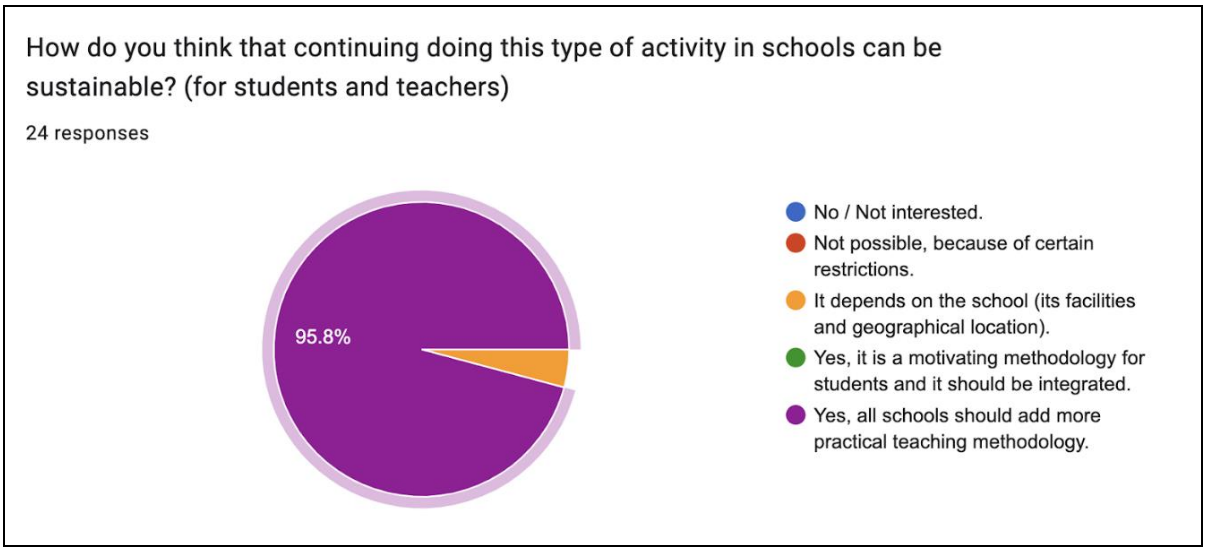

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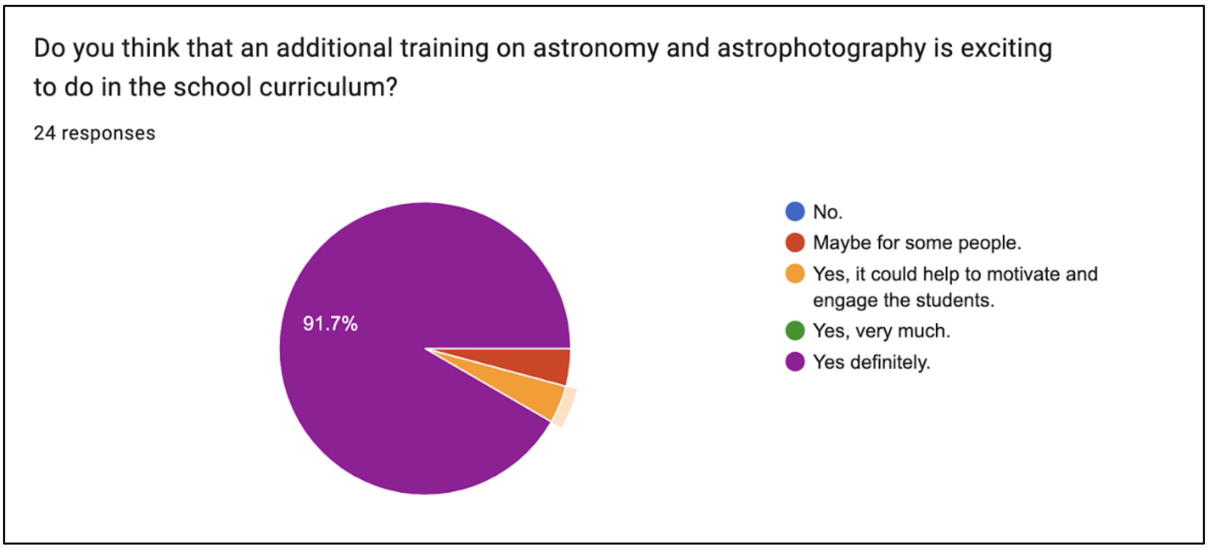

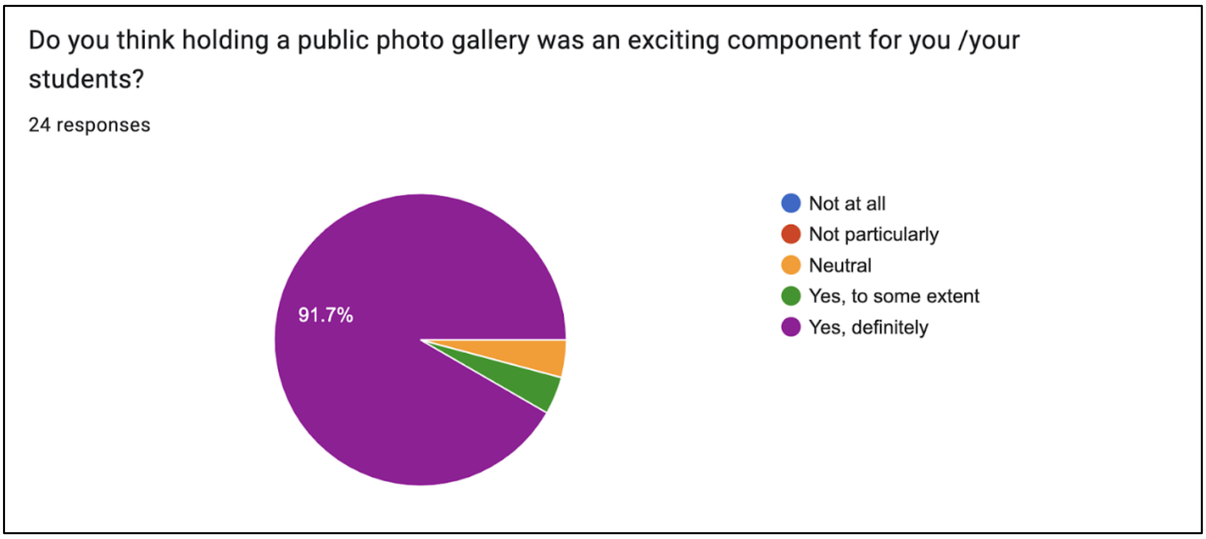

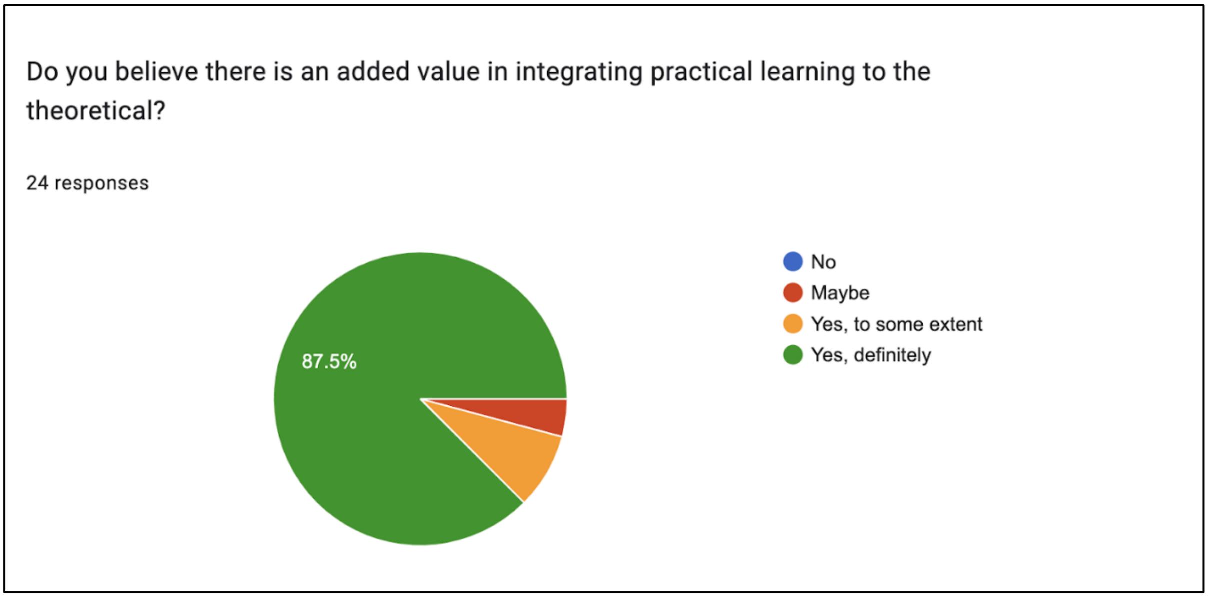

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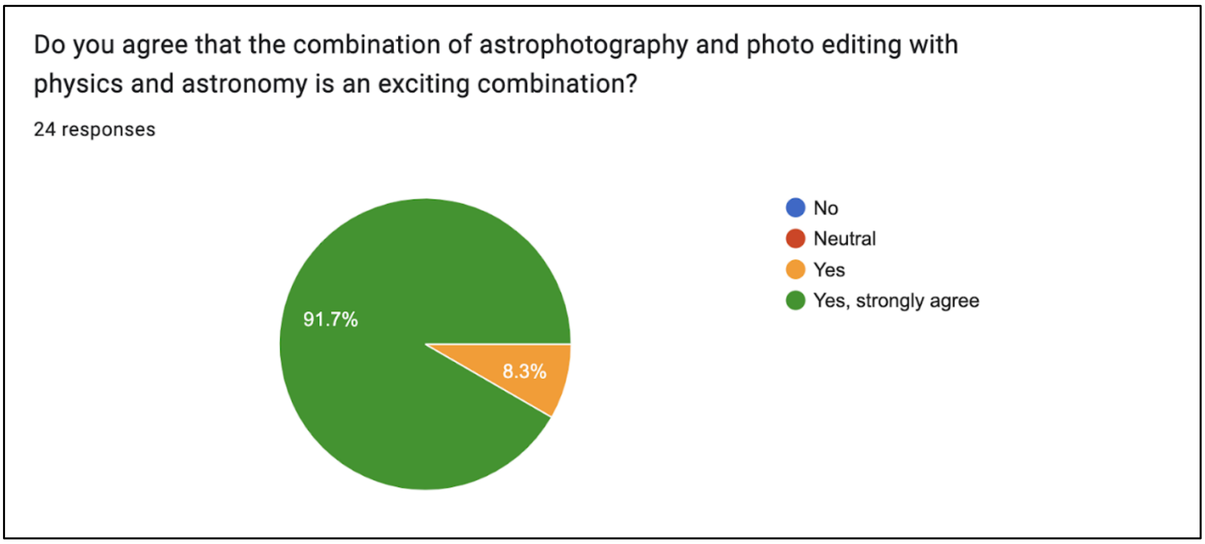

6.2 Qualitative Results: How do you suggest students to be more involved in the practical training, and not be only an observant? (answers from students and teachers)

- There should be some interesting activities and information that grab students' attention.
- We should not depend on the classroom environment. we must learn by doing.
- listening attentively to what is going on around me and asking questions.
- training that will be very entertaining and enjoyable when they observe.
- By organizing fun activities that can attract everyone's attention.
- By doing activities that can attract student's attention
- Engaging students in these topics.
- To offer more practice opportunities and motivate students.
- This was very entertaining and educational.
- Our students should not only participate in this beautiful project as observers but also participate in practice. Participating in practice is both more permanent and more fun.
- We learned new and bright information, we learned how to use a telescope.
- This method was good we learned the stars.
- If we willingly participate in the training, it becomes fun.
- We can learn a lot of permanent knowledge in practical education.

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6.3 What aspects of this training were most valuable, that you think your school should keep doing?

- The best part of this training was getting the chance to look at the sky through a telescope, meeting people from around the world, and getting information about space and astronomy some of the best experiences.
- More hands-on training in Space and Astronomy would be beneficial.
- For traveling and discovering new places and for making people love education.
- There are many things in the sky that we do not know, we must continue this training.
- It was worthwhile to be in a different place with different people.
- Observation education is the most valuable education, we have acquired more permanent information by seeing.
- We are improving with different pieces of training, I think it should be more frequent
- Students get to know students from different cultures and increase their interest in the sky.
- Photoshoots together.
- Very entertaining and educational
- Learning the customs of other countries and making new friends
- In our space project, we learned what a telescope is and how it is used.
- We learned about space astronomy and stars.
- We got information about space, astronomy, and stars, it was very useful information. The most valuable aspect was the education of the information we did not know about space in the most beautiful way visually.
- We learned information about space, astronomy, and stars we learned information about space that you did not know.
- We have seen, recognized, and known the differences in culture, and tradition.
- We can learn new things when we explore space with the ever-evolving technology.
- Practical training
- Everything was perfect. Thank you.
- We could have stayed longer and seen more.

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6.4 What more would you add as a student or teacher to this training in your school?

- As a teacher, I would like all students in the school to benefit from this training. adding innovations
- It can be 1 or 2-week pieces of training, not for travel purposes.
- I prefer this training to be explained more frequently and in more detail.
- Everything was good, I think more may not be good, but you can go to 2 places instead 1.
- By providing more education.
- I make an effort for everyone to see it. I do my best so that they can get to know the space and its surroundings.
- Very entertaining and educational everything about teachers is adequate and good
- We can use the photos in other lessons.
- Such a careful and good education opportunity can be provided in every field.

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7 Conclusion

The European experience that Erasmus+ offers rural schools and students demonstrates that the European Union encourages schools to integrate modern teaching methodologies adjusted to our times. This experience also offers students and teachers alike the opportunity to exchange knowledge, culture and best practices.

As coordinator, trainer, and designer of the Space and Astronomy project, we were very proud to see how the students actively participated in the practical training and how they applied learning about the camera and telescope engineering. The teachers were inspired by the methodology we presented and the schools decided to integrate it along with the training materials and the PowerPoint presentations produced and shared by our organization.

The quantitative and qualitative survey has shown us that the methodology to encourage students to become more passionate about science has been perceived positively and that the suggested methodology is a success among teachers and students.

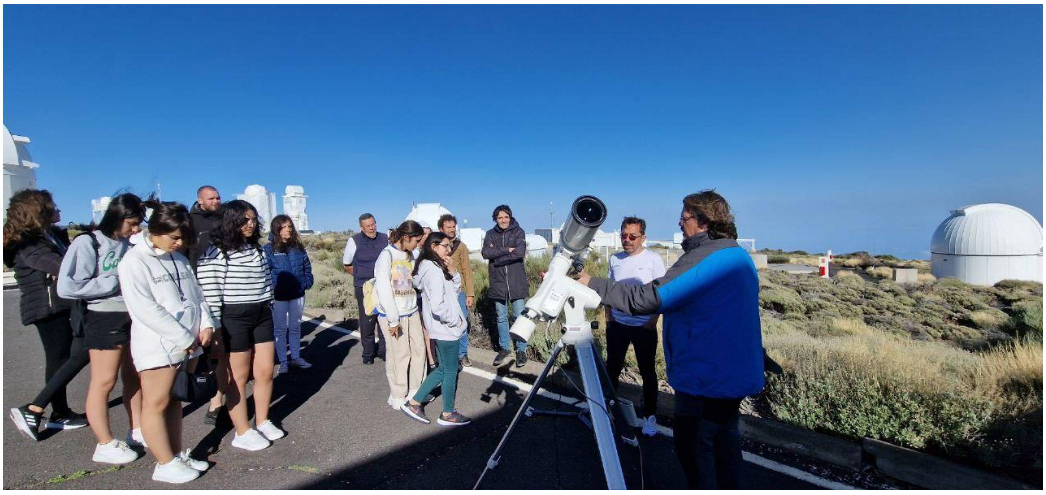

Figure 47: Visit to the observatory of the Astrophysics Center of Tenerife

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