Proceedings for the
3rd Shaw-IAU Workshop
on Astronomy for Education

What Everybody Should Know about Astronomy Education

12 – 15 October, 2021

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Asmita Bhandare, Giuliana Giobbi, Colm Larkin, Rebecca Sanderson, Eduardo Penteado, Niall Deacon, Gwen Sanderson, and Anna Sippel.

The following is a summary of the 3rd Shaw-IAU workshop on Astronomy for Education held 12 – 15 October, 2021 as a virtual event. The workshop was organised by the IAU Office of Astronomy for Education. More details can be found on: https://astro4edu.org/shaw-iau/3rd-shaw-iau-workshop/.

The Office of Astronomy for Education (OAE) is hosted by the Haus der Astronomie on the campus of the Max Planck Institute for Astronomy in Heidelberg. The OAE's mission is to support and coordinate astronomy education by astronomy researchers and educators, aimed at primary or secondary schools worldwide. The OAE is an office of the International Astronomical Union, with substantial funding from the Klaus Tschira Foundation and the Carl Zeiss Foundation. The Shaw-IAU Workshops on Astronomy for Education are funded by the Shaw Prize Foundation.

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Foreword

3rd Shaw-IAU Workshop on Astronomy for Education

Teaching astronomy takes both solid knowledge of the subject itself as well as educational skills, such as knowing appropriate methods and techniques for teaching. To this, specific sub-fields of astronomy education add their own specialized skill sets: knowing how to operate remote telescopes, for instance, or the ins and outs of daytime observations. Last but not least, there are the skills needed in order to make our teaching fair, equitable, and inclusive.

In practice, most of us who are active in astronomy education have only been taught a subset of those skills in our academic training. Those who come from professional astronomy and have branched out into education and outreach typically have advanced training in astronomy, but not in the relevant areas of pedagogy. Most teachers, on the other hand, have pedagogical training as well as training in the subjects their teach, but often that does not include formal training in astronomy and astronomy education.

If this description includes you, and if in consequence you have ever felt motivated to expand your astronomy education skill set, then this workshop was, and is, meant for you. It is the third in a series organised as a collaborative venture between the Shaw Prize Foundation and the International Astronomical Union, and with 89 talks and 50 posters in a total of 18 sessions, it provides a fairly comprehensive “Astronomy Education 101”.

For those who were unable to attend, or did not manage to attend all of the sessions they were interested in, we present these proceedings, and the associated talk videos from the workshop. While they lack the interactivity that the 580 workshop participants enjoyed as they posed their questions to the speakers, or interacted in the chat, we do believe that they are valuable in their own right — and we asked speakers to include in their write-ups helpful pointers to additional resources, so you have the opportunity to delve deeper. If you find these resources useful, and I hope they will be useful to many, please share them widely.

The workshop was made possible by funding from the Shaw Prize Foundation, for which we are very grateful. You can find the names of the individuals and institutions who organised the workshop on p. 6 — a big “Thank you!” to all of you!

For us at the International Astronomical Union’s Office of Astronomy for Education (IAU OAE), this is just the start. Helping those who are active in astronomy education to grow their skills, and to become more professional in their activities, is one of our main objectives. Stay in touch if you want to make sure not to miss what is next — from additional events to more resources. On the web, you can find us at http://astro4edu.org, and on that page, you can also find your country’s National Astronomy Education Coordinator Team. We are also on Twitter and on Facebook as @astro4edu.

Markus Pössel
Director, IAU Office of Astronomy for Education
Heidelberg, November 16, 2021

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In addition to the efforts from the OAE office in Heidelberg, Germany, the following OAE Centers and Node made key contributions to organizing this event:

OAE Center Italy

OAE Center Cyprus

OAE Node Nepal

The OAE Center India was not formally established at the time of this workshop but also made significant contributions.

Naked-eye Astronomy

Session organisers: Anna Sippel, Office of Astronomy for Education/Max Planck Institute for Astronomy/Haus der Astronomie, Germany and Tshiamiso Makwela, University of Cape Town, South Africa and Office of Astronomy for Education, Germany

Session overview

Naked-eye astronomy invites us to enjoy and learn about the night sky without any optical aid or a telescope. In theory it might seem easy to simply look up and dive into the world of stars, but in practice is often difficult to achieve. Some of the contributing difficulties include: light pollution, night sky observations cannot be carried out during regular school lessons, and our modern world provides us with many distractions preventing us from looking up at all. As such, this is one of our main tasks as educators & practitioners, to encourage and motivate students to overcome this first step. In addition, observing the night sky with no tools is an activity that many professional astronomers have little experience in. However, learning about the night sky can help us overcome our fears of the night, and unlock the wonders of the sky.

This session guided us from theory to practice and application of various aspects that enable us to plan projects related to Naked-eye astronomy, and our enthusiastic speakers shared very valuable experiences. Various possibilities were presented to provide students as well as the public, with different backgrounds and interests an invitation to the night sky. This can be via the use of a mobile phone app to get started until the use of a planisphere is learned, night sky observations at observatory or historical sites or even in a café in a city.

TALK CONTRIBUTIONS

Astronomy Diaries and their Effect on Students' Understanding and Attitudes

Speaker: David R. Gozzard and Marjan G. Zadnik, University of Western Australia, Australia

Traditional lectures have been shown to have limited effectiveness in conveying unfamiliar concepts. To increase student engagement and understanding of concepts students in an introductory astronomy course were instructed to record and analyze their naked-eye astronomical observations over a semester. Pre- and post-course evaluations including an astronomy concept diagnostic test and an attitudes survey were used to determine the effect this activity had on students' learning. The results suggest that observing diaries are a positive learning experience for the majority of students. However, the diary task must be carefully integrated into the course content to derive maximum effectiveness.

Talk link: https://youtu.be/JS2Bcj-QKmU

Setting students the task of recording their own regular observations of the night sky, and getting them to analyse and reflect on what they observed, can help students to learn basic astronomy concepts that traditional lecture-style classes often fail to convey. When used properly, astronomy diaries help to promote students' engagement with the course material, allow students to express their own creativity and preferences, and benefit students who struggle with exam-style assessments. However, the diaries take a lot of effort on the part of both the students and teachers, and must be weighted accordingly in the marking scheme. For maximum benefit, an assessment involving astronomy diaries should include a set of compulsory observations, guided observing opportunities, early feedback on students' efforts, and an emphasis on analysis and discussion of their observations.

Introductory astronomy courses have proved very popular with students not majoring in science, technology, engineering, or mathematics degrees needing to fill the science portion of their general education requirement. As a result, such "astronomy 101" classes have become very important because they are often the last formal science education a student may receive, and so the last chance to influence their science knowledge, literacy, and support for science.

Students' understanding of key phenomena, such as the cause of seasons and phases of the moon, are fundamental to understanding other scientific concepts, and making sense of new research findings reported in the media. However, traditional methods of teaching (i.e., lectures and exams) are not as effective as we would like for conveying new concepts, and are particularly ineffective when students come to a class with prior, inaccurate, conceptions about how their reality works. Students are capable of reproducing what they have been told, but they have not internalized the information and understood the concepts, and they cannot apply what they have learned to new situations.

'Observation journals' are commonly used for teaching and assessment in fields such as biology and conservation. Students are instructed to keep these journals to record, in detail, what they see in the field, in order to hone their observation skills. Observation diaries have also been advocated for use in astronomy education as a way of increasing student engagement, and improve their understanding by encouraging them to see astronomical phenomena for themselves.

We gave our students the task of keeping a diary of their own naked-eye astronomical observations over the course of the semester. As well as assessing the presentation of the diaries and students' reflection and analysis of their observation, we also used a pre- and post-course test to assess how students' understanding of astronomy concepts improved, as well as how their attitudes to astronomy and science changed. By comparing the results to a similar astronomy unit that did not include the diary task, we were able to analyse the effects the diary task had on students' understanding and appreciation of astronomy.

Results: We found that, at the start of the semester, there was a large disconnect between our students' appreciation of 'science' versus 'astronomy'. On average, our students believed that astronomy was both more difficult and less useful in their lives. By the end of semester, students' positive attitudes towards astronomy had improved and come closer to par with their attitudes towards science in general, more so for the class with the diaries than for the class without the diaries.

Many students put a large amount of effort and creativity into their diary, suggesting the diaries did stimulate greater engagement with the assessment task. A number of the diaries included very good illustrations or other artistic flair. Some students chose to blog their observations, and two even chose to present multimedia diaries using PowerPoint.

The results for the astronomy concept tests show that the class that used diaries did experience a greater improvement in their understanding of the concepts, but the size of the effect was smaller than hoped. We also compared students' marks for the diary assessment with their marks for the final exam and found very weak correlation, which indicates that tasks such as the astronomy diary may suit some students who normally struggle with traditional assessment methods.

Using astronomy diaries in the classroom: Based on our research and the results of other studies on astronomy diaries and other forms of observational journal assignments, we have several recommendations for how to effectively implement an astronomy diary task.

Setting the task – Show students examples of previous diaries to indicate what is expected of a good diary. Allow students to choose the format of their diary, in order to allow them to exercise their creativity, as long as their chosen format is able to convey the necessary information. Pick a free astronomy app (the authors used Stellarium) to help students navigate the night sky, and show them how to use it. Provide students with the marking rubric at the start of the assessment. (An example rubric is shown in the table below.)

Guidance – Set compulsory observations that the students must complete in the first four weeks of the semester. Recommended compulsory observations are: 1) observe the position and time of four sunsets (or sunrises), 2) four observations of a planet moving against background stars, and 3) four observations of the Moon on consecutive days. Run a teacher-guided observing session with the students. This must be done as early in the semester as possible because students are resistant to changing their observing practices once they have established a routine.

Early feedback – At the end of the compulsory observation period, give feedback and an early or indicative mark to the students to help them adjust their observing or reporting practices. Discuss the diaries and observations in class.

Marking – Emphasize the need for reflection and analysis of accumulated observations in the marking in order to guide students towards deeply considering how the sky changed over the course of the assignment and the pattern that emerged. Encourage students to draw diagrams to explain the reasons for the phenomena they are seeing. The assessment should be appropriately weighted (20+% of the course total) to reflect the level of effort students should (and do) put into the task.

Assessment scale: 5 - excellent, 4 - very good, 3 - satisfactory, 2 - acceptable, 1 – unacceptable, **0 – not done**

Diary clearly organized, i.e. used a consistent or systematic method of reporting observations	5	4	3	2	1	**0**	Diary disorganized
Interesting diary, e.g. contained images, photos, drawings, alt/az bearings	5	4	3	2	1	**0**	Boring diary. Did not contain:
Considerable effort, i.e. many (more than 10) detailed observations spread over semester. Compulsory obs done.	5	4	3	2	1	**0**	Very little effort, rushed with few observations.
Included reflections/comments on observations and analysis of data.	5	4	3	2	1	**0**	**No comments or analysis – just data.**
Included discussion of the analysis and conclusion drawn.	5	4	3	2	1	**0**	**No discussion or conclusions**
TOTAL (/25)							

Students’ Mental Models about the Apparent Motion of the Sun and Stars

Speaker: Hans Bekaert, KU Leuven, Department of Physics and Astronomy and LESEC, Leuven, Belgium

We administered the AMoSS test with 12 multiple choice questions, which focus on distinctions between different aspects of the apparent motion of the Sun and stars, to 16-17 years old students of 6 Belgian secondary schools (N=410). We also asked them to explain their choices. The analysis of their answers reveal that, despite instruction, most students only demonstrate a rudimentary understanding of the apparent motion of the Sun and stars for different locations of the observer and different times during the year. On top of that, there is a clear distinction between the replies for the Sun and stars. Thanks to the classification system we have developed to categorize the explanations, we are able to identify different student mental models about the apparent motion of the Sun and stars.

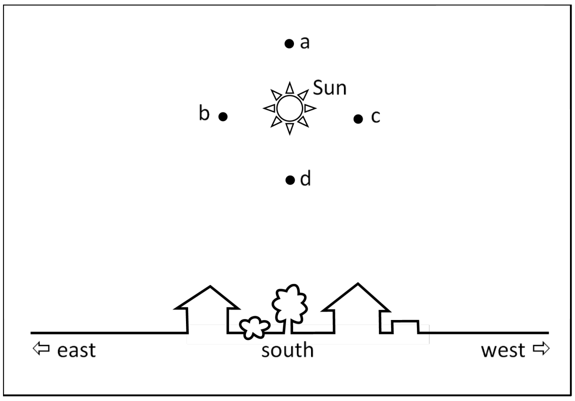
Talk link: `https://youtu.be/XiOLWjgEioE`

Problem Statement

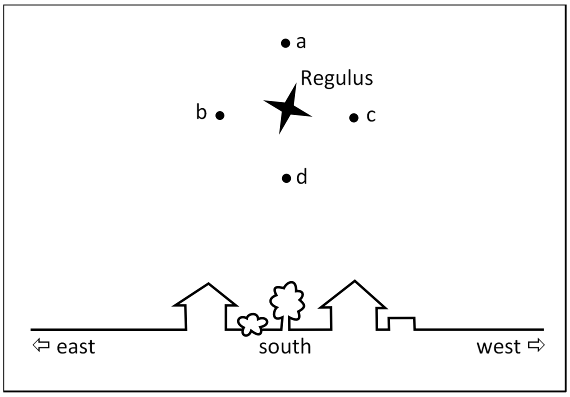
Although the apparent motion of the Sun and stars is part of our daily life, research reveals that many students have alternative conceptions about this phenomenon (Slater et al., 2015; Plummer, 2009; Vosniadou & Brewer, 1994; Trumper 2001). However, only little is known about students’ understanding of similarities and differences between the apparent motion of the Sun and stars. This study focuses on these differences and similarities. We therefore designed a framework to disentangle different factors that influence the apparent motion and to compare the different aspects for the Sun and stars in relation to the time of the day, time of the year and the observer’s latitude. For each factor we designed test items, also inspired by literature. This resulted in the AMoSS test[1] (Bekaert, 2020) with 12 multiple choice questions: 6 questions about the Sun and 6 parallel questions about the stars. For 6 out of 12 questions, we also asked students to explain their answer. Figure 1 shows the first two questions of the AMoSS test as an example of two parallel items.

We administered the test to 410 high school students (16-17 years old) during a science class. Based on the multiple choice answers, the mean score for all participants on all questions was M = 45%, SD = 18%. On average the six Sun questions (M = 55%, SD= 24%) were answered more correctly than the six star questions (M = 36%, SD = 21%). Bottom up from the student explanations, we have designed a classification system to categorize these written explanations. This categorization system should give us insight into the students’ mental models about the apparent motion of the Sun and stars. In this paper we report on the mental models we have

[1]The work was co-funded by the Erasmus+ program of the European Union (2020-1-IT02-KA201-079528).



Question (a): On March 21st, an observer in Brussels sees the Sun in the south high above the horizon as shown in the figure. Where does this observer see the Sun one hour later?



Question (b): On March 21st, an observer in Brussels sees the star Regulus in the south high above the horizon as shown in the figure. Where will this observer see Regulus one hour later?

Figure 1: Two corresponding questions: (a) The apparent motion of the Sun. (b) The apparent motion of stars.

identified, based on the classification of the students' written explanations and a statistical analysis (Latent Class Analysis) of the multiple-choice answers.

Students' mental models

For a more detailed understanding of how students explain the phenomena of apparent motion, we try to identify their underlying mental models. Although there is no agreement about the exact definition of a mental model, in general, the term refers to the internal representations that people form of the outside world through their interaction with it. Bao (Bao, 1999) put forward his definition of mental models by considering other descriptions in the literature. According to him, mental models are "*productive mental structures that can be applied to a variety of different physical contexts to generate explanatory results*" (p. 13). Corpuz and Rebello (Corpuz & Rebello, 2005, 2011) defined a mental model as "*students' way of understanding a certain physical phenomenon*", which can also be unseen physical phenomena. Mental models may contain contradictory elements and are generally different from scientific models, which are accepted as valid if they are coherent, stable, and experimentally validated.

A latent class analysis of student answers on the different questions together with our classification scheme, allowed us to identify four specific mental models that students use to explain different aspects of the apparent motion of the Sun and stars. Apart from these models, we realized that many students are very incoherent in their explanation and do not show consistent reasoning to explain the apparent motion of the Sun and stars.

Administering the Apparent Motion of the Sun and stars test (AMoSS) with a group of Belgian students of the fifth year (16/17 year olds) of secondary education (N=410), allowed them to identify several mental models that students use to explain their answers.

In the presentation, the different mental models about the apparent motion of the Sun and stars, will be discussed in detail.

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Inviting Students and Teachers to Look Up!

Speaker: Julie Bolduc-Duval, Discover the Universe, NAEC Canada, Canada

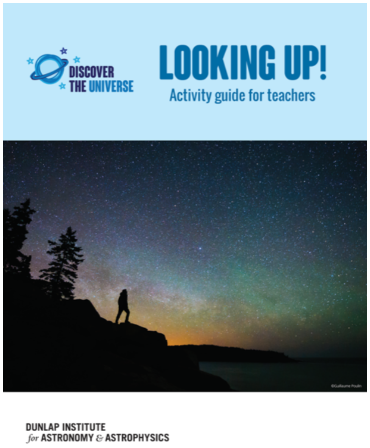
Astronomy is all about observing the sky, but teachers rarely do it with their students. There exist many activities to explore the sky during the day and at night, from a rural area as well as from a city. We will present many ideas which we brought into an educational module named Looking Up! available in English and French. The activities can be adapted to many grade levels and require very simple materials. We strongly believe that discovering the sky allows students to connect with their environment and learn about a lot more than just astronomy.

Talk link: https://youtu.be/62UsFlMMqfI

In our busy everyday life, we do not tend to pay much attention to the sky. We rarely look up, day or night, and most of us unfortunately do not feel a connection with the sky. It is a sad reality since there are many objects and phenomena that can be observed easily, during the day or at night, and from everywhere, whether you live in a city with a lot of light pollution or in a rural area with pristine night sky. We feel it is important to invite teachers and their students to look up to reconnect with the sky and their environment. Spending time outdoors and observing our surroundings allows us to better know, understand and appreciate our environment. And this impact goes beyond astronomy: developing one's own experiences in nature is essential to be connected to the land and the different species that live there.

Educational module *Looking Up*! Observing the sky and the different visible phenomena can be very rich and bring beautiful discoveries for everyone, especially students. We created the educational module Looking Up! with that goal in mind: to enable students and their teachers to discover the sky easily and without complicated instruments. It consists of eight simple activities enabling students to learn more about the Moon, the Sun, the Earth and its motions, as well as the stars and constellations. The activities can be adapted to many grade levels or age of the students. While some of the content connects more closely to the grade 6 school curriculum in many provinces here in Canada, we have adapted some of the activities to lower and higher grades before. We hope you can get inspired by this educational guide and we invite you to adapt the activities to your own reality, especially if you live at latitudes much different than about 45 degrees north. This educational module can be downloaded for free on our website at www.discovertheuniverse.ca/resources. It is also available in French at https://www.decouvertedelunivers.ca/ressources.

Observing the Moon: The Moon is the easiest celestial object we can observe directly and easily. Students could keep a Moon journal for a month to discover its phases. The goal is to observe the Moon as often as possible during a full lunar cycle. Obviously, it will be impossible to observe it every day, since clouds will be present. It is OK: you do not need daily observations



to observe patterns and understand how phases work. Invite them to observe often, day and night. Young (and not so young) people are often surprised when they notice the Moon in daylight for the first time! When the Moon is visible during the day, you can bring balls outside to model the phase of the Moon. By holding the ball under the real Moon, the ball will show the same phase as the Moon. This simple activity allows students to realize that the Moon is always a sphere, and that its phase is simply the result of how the Sun lights the Moon and our perspective here on Earth.

Observing the Sun: While we do not recommend direct observing of the Sun for your eyes' safety, there are ways to study the position of the Sun to notice differences throughout the year. These observations can then be tied to concepts about the Earth's rotation and revolution around the Sun. Students can be invited to study daily or seasonal cycles by paying attention to the position of the Sun over a certain period. An easy way to do this is by measuring the length of a shadow many times in a day and comparing. Another great activity for students is to pay attention to the position of the Sun as it sets. They could draw the horizon looking west from their home and draw the position of the Sun once a week or so to notice differences. If students have access to digital cameras and are up to the challenge, they could take pictures of the sunset over a long period and create a video with all pictures. They might be surprised to realize how much the Sun moves on the horizon between the summer and winter solstices!

Observing the Stars: Observing the stars and constellations might be harder if you live in a light-polluted area. You could still invite students to learn more about the stars using a star finder or a sky map. You could also discuss light pollution and have them measure the light-pollution level where they live. We highly recommend the program Globe at Night (`www.globeatnight.org`), which provides maps of how specific constellations would look under a dark sky vs a light-polluted sky.

Observing the sky is the basis of astronomy and each of us can learn more about the universe simply by looking up more often. Whether in the school yard, in the park or at home, simple activities can be carried out to "live" astronomy instead of just passively learning it. This experience will be even richer for budding young astronomers and will create memorable experiences for all.

Naked-eye Astronomy Projects

Speaker: Shylaja B S, Jawaharlal Nehru Planetarium, Bengaluru, India

I would like to broadly classify them in to day time and night time astronomy projects. In the daytime projects involving the sun, shadow measurements at meridian passage was one of the most successful project. There were a few related to the moon as well. Although the night sky offered very little scope for the urbanites I utilised the passages of HST and other bright (artificial) satellites for a few practical sessions. The most popular among them was with the local radio stations which gradually got converted to Whats App sessions last year. The occultations, conjunctions and meteor showers also offered a good opportunity. I will quote some examples and possibility of exploiting these ideas for the current pandemic era.

Talk link: https://youtu.be/4a0p5QGuWMI

Today, in the era of space age, observing with naked eyes still holds the key to understanding the universe. Thus even before using the digital gadgets, we need to get the basics right and that is possible only by naked eye observations.

The sky watch actually begins in the day observing the sun. However, we will restrict our discussion to the night sky only.

The easiest object to start sky-watching is the Moon, which not only tells about its own motion among the stars but also about the stars in the background. Noting the phases and the repeatability may appear to be a routine thing that loses charm in no time. But finer details like the liberation and the visibility of craters throw challenges. Eclipses, both lunar and solar, offer a great opportunity for naked eye observations - something a camera cannot capture. One of the best examples is the sky brightness measure, which hints at the solar activity in case of solar eclipse and the volcanic dust content in the earth's atmosphere. The gradual emergence of stars in the vicinity of the moon as the eclipse progresses into a pitch dark sky is an interesting to watch and enjoy. The colour of the eclipse moon also is an enjoyable sight. More so if it has a star cluster like Preasepe or the nebulosity of the Milky Way nearby. The penumbral eclipse is another challenge for naked eye observers (see https://apod.nasa.gov/apod/ap161012.html). I recall an elderly man of 80 calling me to check if something was "wrong" with the southern tip of the moon. Having observed the moon for over 60 years he was able to recognise the penumbral shadow.

The orientation of the crescent moon to the horizon varies from month to month and also with latitude. All these offer great opportunities for those with a skill in painting.

More familiarity with the moon and its motion will make one look for occultations, close conjunctions with planets and bright stars. The passage of the Moon through clusters like

Preasepe is an enjoyable sight indeed. This also makes one ponder at the not-so-interesting repeat performances after occultations exactly 28 days later.

High tides are well-known along the coast; the periodicity associated with it is also known to fisher folk. Few students monitored the height of the tides through the month. They were able to identify the effect of perigee and apogee even when the events did not coincide with the new or full moon. This was one of the most effective ways of debunking the myth of the "super Moon".

One of the challenges faced by all sky gazers is to mark a lunar analemma. The solar analemma is quite simple to achieve. In the case of the moon the figure of 8 will have different orientations throughout the year. This can be best rendered as a hand drawn picture or with images from a very simple aim and shoot camera. (see https://apod.nasa.gov/apod/ap200507.html) The other type of objects that attract the naked eye observations are the planets. Here again, the mutual conjunctions and bright stars provide great opportunities. Last year the passage of Venus through the star cluster Pleiades offered a great opportunity. The conjunction in December 2020 when Saturn and Jupiter approached each other with a small angular separation was used to test the detectability of the limit of naked eye observations.

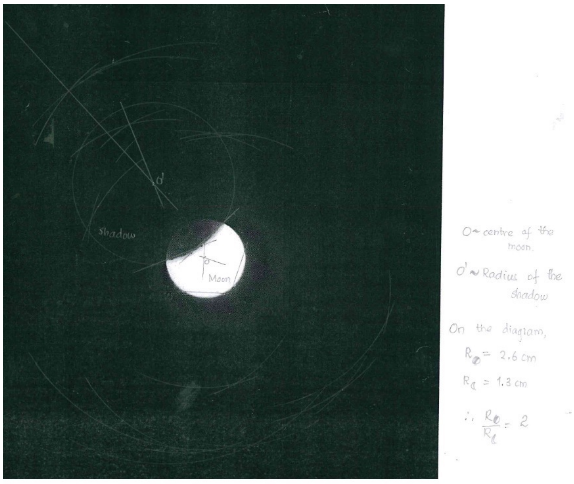
Twilight has always been a delight to watch and enjoy. It is interesting that an estimate of the duration and the richness in colours done 100 -150 years ago resulted in the important deduction of the effect of volcanic dust on twilight. Spending a couple of minutes watching the colourful sunset and twilight can give clues on the volcanic dust content, which renders the sky more colourful and extends it to a much longer duration.

Concepts like heliacal rise and set can be easily understood with naked eye observations. The light pollution, in today's context and the visibility of the horizon play an important role in establishing the sightings of heliacal rising as well as the youngest moon.

Bright comets like Hale Bopp and NEOWISE offer a great opportunity for naked-eye observations. There have been interesting reports of "detachments" - ejection of a knot-like structure in the tail of comets - by naked eye observations in the past. Meteor showers are best enjoyed with naked eyes. The cell phone camera can be of some assistance.

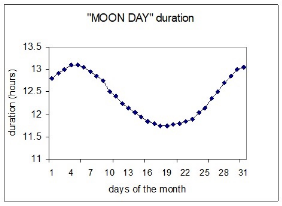
When we try to observe the stars and constellations the challenges are many. The planetariums and sky apps on the mobile phones offer short quick dosages like capsules - a natural, nourishing, vitamin rich dosage should be procured by patient sky watch sessions only. Beginners find it extremely difficult to identify the constellations. More so under a light-pollution free sky. One of the earliest attempts here in Mysore (almost 50 years ago) was with the radio guided tour. The listener would move to his terrace with the radio and just a handy 30cm scale. The dates for these broadcasts would be chosen around the first quarter, so that the moon is available as a guide. This was very effective and achieved a very vast geographical coverage. The purpose of the scale was to guide the listener to the stars around the moon - it would be held at arm's length and the reading would help them identify the star. This kind of exercise would also help in star-count exercises, which can indirectly hint at the effect of light pollution.

After establishing the familiarity with constellations and star charts, one will mature to observe variation in brightness of stars as was done by the young boy John Goodricke 300 years ago.

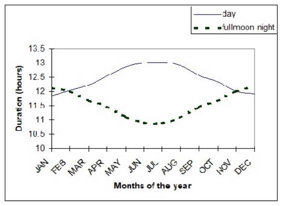


Estimation of the diameters of shadow and moon by Godvin, a student

A simple exercise of observing the rise and set time of the moon throughout the month led to a very interesting discussion in the class room. The duration of the full moon night through the year also generated lot of discussion.



The variation of the "moon day" - interval from moon rise to moonset - in a month



The variation of the duration of full moon night as compared with that of day time.

The drawings and photographs of the lunar eclipse was used by school students to get the radius of shadow and the radius of moon.

This is the age of digital gadgets. Therefore the group calls, chats (the order of the day during the pandemic) serve the sky watch sessions very effectively. We found this especially useful during December 2020 for the great conjunction event.

The artificial satellites are a big problem for sky watch. However we can use them to our advantage. I found the passages of ISS especially useful for introducing the names of the constellations to the beginners. The session would be planned for about 15 minutes to have the ISS passage in between. Thanks to Heavens-Above.com, (Alok.com and Xavier Jubier) the charts could be provided well in advance. The constellations along the path were introduced before the event. The identification would be attested when the ISS arrives - this dot in the sky serves as a pointer. The accompanying audio commentary helps the listener to correct himself if he made any mistakes. The commentary continues after the event to guide them to other constellations. Occasionally even HST would grace the sky for a second session through different sets of constellations. For children it is fun. For adults the accuracy of prediction is a wonder. In any case, this short break from routine drives them towards the sky - an exercise long forgotten.

Promoting of Astronomy through Naked-eye Observation on Heritage Sites

Speaker: Siramas Komonjinda, Chiang Mai University, Thailand

Many Heritage Sites were built based on the knowledge of Astronomy. Without any instruments, people in the past observed astronomical events, recorded and analysed them. They could systematize their observations and find their own astronomical knowledge. In this talk, we will present the work of the Archaeoastronomy Research Group in Thailand. Many heritage sites were built using ancient astronomical knowledge. During every visit visit to these monuments, astronomers observe the Sun, the Moon, and the stars of the ancient people. These engage the interest in Astronomy from archaeologists, historians, and the public. It is promoting local knowledge which made locals interested in Astronomy, both ancient and modern.

Talk link: https://youtu.be/Gl0gB2W0zDY

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Astronomy is one of the oldest knowledge of humans. Since hominids started to understand things around them to form the early communities, they observed the Sun, the Moon, planets and stars. They counted the date between each full moon, positioned the Sun of each sunrise and sunset, and checked the position of wanderer stars. For example, a bone found in Thaïs cave, close to Saint-Nazaire-en-Royans, France is a part of a bovine rib engraved with lines that might be related to Luni-solar time record. It is dated back to 12000 years ago. (Portal to the Heritage of Astronomy, 2021)

These kinds of observations create systems of calendar of their own in many cultures. Calendars might be based on Moon phases (lunar calendar), Sun position (solar calendar) or both (luni-solar calendar). Planets may also appear in some cultures, especially those with Chinese influence, i.e. 60-years cycle which is related to the Great Conjunction between Jupiter and Saturn.

Even though these people are naked-eye astronomers, they used many kinds of instruments to observe; from small instruments like a quadrant to large instruments like the monument. Many heritage sites of several cultures were built to support these ancient astronomical observations. Recently, the Chankillo solar observatory and ceremonial centre has been inscribed on the World Heritage list. This is a prehistoric site (500-200 BC) in Casma Valley near the north-central coast of Peru. A thirteen cuboidal tower runs north-south. From the observing site which is 3 km away, the Sunrise could be observed at the gap between each tower. From Summer solstice to Winter solstice, the towers are interpreted as horizontal markers for solar observation (Portal to the Heritage of Astronomy, 2021).

Archaeoastronomy sites in Thailand

Thailand, is a country which well-known in her rich of cultures and natural resources. Many historical sites are popular for tourists, including Ayutthaya (Siam Capital during 14th – 18th Century) and Sukhothai (Capital of Sukhothai Kingdom during 13th- 14th Century). However, the country which was known as Siam is actually a combination of many kingdoms of the past. Until these days, a tourist will find the difference in culture, language, and food between each part of Thailand. These are the heritage of the long history of the descendent of those kingdoms. For example, Lanna Kingdom, which became part of Siam in the late 18th Century was an independent Kingdom from 1262 AD, and Chiang Mai was its capital from 1296AD.

Nevertheless, the cultures were exchanged between these kingdoms and also with the surrounding kingdoms such as Khmer Empire or Pagan Kingdom (presently part of Myanmar) or influenced by China and India. This creates a specific knowledge in many subjects, including astronomy.

In our research, several heritage sites were studied in their relationship with astronomical knowledge, especially those in Lanna and the South-eastern part of Thailand. They are mostly Buddhist monuments related to the 10th – 13th century. These places are not only religious monuments but also used as astronomical instruments.

For example, Prasat Hin Phanom Rung (Phnom Rung Stone Castle) in Buriram, a Hindu-Buddhist temple complex of Khmer Empire which dates back to the 10th century, was restored in the 1970s – 1980s. The sunrise phenomena which can be observed twice a year through the main part of the complex attract people to observe. (Komonjinda, 2011) Recent studies (Saelee et al., in prep) indicate that the alignment of this temple reveals the relation with the observation of Spica and could be used for the intercalary-month year in the luni-solar calendar that was used in the area.

Naked-eye Observation at Historical Sites

In order to analyse the usage of astronomical sites, researchers have to collect naked-eye observation data from the site as it was done by ancient people. Although the observation can be simulated from modern technique, to understand what people did and gain the same environment, one has to be in the same situation. Researchers also have to be patient as some phenomena could be observed once a year.

To conduct this observation, it is required special access to the national reserve area both during the tourist visiting time and after dark and a long term observation. This activity interests people by many means. Archaeologists and historians can gain the experiences on how ancient people used the sites. This could help them understand more about the site such as the interpretation of inscription. The observation also supports tourism. The knowledge of astronomy can make the story of the site more interesting and the observation experience can gain tourists an invaluable experience.

The most important thing is the impact on local people. Many historical sites were abandoned as it was useless by means of present day activity. The knowledge of astronomical use of sites should be spread out, not only to keep the site persistent but also to take pride in local knowledge.

In 2020, the National Astronomical Research Institute of Thailand plans to have a training program on Archaeoastronomy including the Naked-eye observation. But due to the COVID-19 pandemic, the training was postponed to 2021.

For more than thirty years, the integrated learning to the unified concept technique was initiated and used at Chiang Mai University to train undergraduate Science students and later apply for high school students in science classroom in university program (Wongta et al., 2019) The program found a success story as it gives the new generation scientist understand the relation between science and history.

The Citizen Night-sky from Valparaíso

Speaker: Sebastián Ramírez Alegría, CITEVA, Universidad de Antofagasta, Chile

During the summer of 2016, in a small bar in Valparaíso (Chile), there was talk series dedicated to the night-sky observation. The activities were open to anyone interested and focused on recognizing several objects in the sky using only our eyes. The participants started recognizing their knowledge, realize the challenges (both temporal and spatial) associated with observing the sky in the city, and finished observing different celestial objects in the summer night. In this talk, I will present this brief project, its activities, problems, and main learnings -for participants, myself, and future projects.

Talk link: `https://youtu.be/0iCHdU1aM6k`

Disclaimer: This text is a composition of opinions based on my experience in Chile as a professional astrophysicist doing outreach. Please consider I am not an expert on outreach activity design.

For most of us, the first experience of the sky at night is using only our eyes. But with time, we are exposed to high-resolution and astonishing images of cosmic objects: planets and their satellites, nebulae with a variety of colorful shapes and shades, multitude of stars crowding the central region of star clusters, or galaxies grouping and deforming themselves into galaxy clusters.

These beautiful images require special equipment, previous technical knowledge, and time for acquisition, reduction, and construction. The general public does not consider the last two groups of needs (knowledge and time) as a mandatory requirement and usually gets captivated by the idea: "to observe the sky, I need a (powerful) telescope." Many of the questions received at the end of outreach activities in Chile reflect this general idea: "what telescope should I buy?" or "where can I buy a not-so-expensive but very-powerful telescope?".

A telescope is an instrument to amplify the spatial resolution for a reduced field of view. When we attach a camera, it also allows us to record the image and store the observed photons during a specific time (the "exposure time"). This characteristic makes it possible to record -and observe- dim objects and fine details in the sky. The telescope also has some disadvantages: it requires some basic knowledge of optics, is expensive and fragile, demands technical knowledge for its proper calibration and operation, and may need updates -with an associated cost- to improve our cosmic exploratory experience. And for many users, the smaller field of view and the monochromatic images are reasons for feeling disappointment.

No matter how large the telescope, stars are so distant they will always appear as dots. In the case of planets, colors look pale compared with high-res images. A combination of both phenomena affects nebulae and galaxies: distances pale objects hard to resolve[2]. For these reasons, buying a telescope may not be the best advice for a new explorer of the skies, particularly in a city[3].

On the other hand, the naked-eye sky is a low-cost natural activity, accessible for most inhabitants of a city. But this simple idea is not common to recognize. Trying to introduce the different observable objects using only our eyes in the night sky, I participated in a short workshop called "Cielo a Ojo Desnudo." This workshop invited anyone around the "Trabalengua" cafe in Valparaiso to two activities:

1. A regular talk by an astronomer (myself) about the objects observed in the night sky: this talk was relaxed, inviting to share experiences and trying to remember what every participant had seen during the night. The Moon and stars were the most mentioned objects. With the help of panoramic photographs (Figure 1), we recognized planets ("these tingling dots in the sky, following the solar and lunar path"), star clusters (such as Pleiades and Hyades), and galaxies (the Large and Small Magellanic Clouds, plus our own Milky Way) as part of the "daily" night experience. After mentioning a variety of objects (human-made objects, planets, stars, the Moon, galaxies, clusters), I commented on the physics associated with them, and some examples of the ideas are:
   - Gravity puts together stars in "stellar clusters" or "galaxies." "Constellations" are a group of stars projected by chance in the sky close to each other.
   - The stars twinkle due to the atmospheric turbulence plus their tiny apparent size. They are very distant and hot objects, with different colors from red (cool stars) to blue (hot stars) and beyond (millimeter/submillimeter, infrared, ultraviolet, X- and Gamma-rays).
   - Planets do not twinkle despite the atmospheric turbulence. These objects look slightly bigger than stars and reflect the sunlight.

2. A night-sky observation in the city. After a short walk (less than 5 minutes), we reach an open place in the Playa Ancha's hill and start recognizing objects in the sky. With a finding chart printed before the activity, we see the difference of brightness and source distribution in the sky (understanding part of the Milky Way's structure), how the Moon

[2] To separate individual objects in the image. For distant objects, their details merge, forming a single source.
[3] Highly light-polluted cities forbid their inhabitants from this experience. Better illumination may recover this natural resource.

Figure 1: The night sky at Cerro Paranal, during the lunar eclipse of 21 December 2010. This panoramic photo shows the Milky Way, Venus, Saturn, the Zodiacal light, the Magellanic Clouds, and some easy to recognize constellations in the Southern sky. Credit: ESO/Y. Beletsky (CC BY 4.0).

> and planets move through a narrow path (the ecliptic), and the astronomical origin of the cardinal points. We realized the limited use of the finding chart for a specific night and hour, because of the changes in the sky, due to the Earth rotation and translation movements.

Because the activity occurs in the city, all participants experience the effects of night pollution when they try to observe stars at different parts of the sky (closer to the hills v/s closer to the zenith). Because it happens in their neighborhood, the cost is low and connects with their night sky (it is part of the city and the neighborhood).

This activity happened only in February 2016, but the general talks continued for two more years. The participation in the 2016 series was good; most of the participants attended all the workshops/talks: astronomy, knitting, bread-making, and mathematics. The general cross-disciplinary interest reflects the spirit of Valparaíso's inhabitants and the city itself: one of the main ports in the Pacific at the beginning of the XX century, host of many Chilean cultural explorations: film recording, football club, newspaper, astronomical observation with telescopes, firehouse, and a long etcetera, happened first in Valparaíso.

Star Stories at Kottamia Observatory

Speaker: Ola Ali, National Research Institute of Astronomy & Geophysics, Egypt

Every year, hundreds of astronomy lovers visit Kottamia Observatory to enjoy the clear sky and learn about astronomy. Whether they are school students or adults, the observatory staff always creates a program that suits each group. Mostly, I prefer to work with kids 6-15 years old. At this age, kids are fascinated by the sky and are passionate to learn all about it. When designing a program about astronomy and night sky, I like to integrate stories from ancient astronomy mythology. This provides a fun learning experience and keeps the attention of my audience. Over the years, the outcome of these visits has been amazing. Some of my students choose astronomy as graduation projects. Others even chose to pursue astronomy academically.

Talk link: https://youtu.be/_jjBjxbebqQ

National Research Institute of Astronomy and Geophysics (NRIAG) is a Research Institute that follows the Ministry of Higher Education & Scientific Research here in Egypt. It has 2 main Divisions: Astronomy & Geophysics, It has 5 departments, 12 laboratories, around 300 staff members, and tens of facilities all over Egypt. NRIAG has a very long history of astronomical and Geophysical observations since it was established in the year 1839 as a Royal observatory at Bollak then moved to ABBASIA in the year 1868 before it was moved to the current location at Helwan in 1903; making it the oldest research institute in North Africa and becoming one of the world heritage sites in Science and technology.

Besides its role in scientific research, NRIAG has a great role in community services and the dissemination of scientific culture; especially in the field of Astronomy. One of these services is publishing simplified scientific information throughout different social media platforms, such as Facebook, Twitter, and Instagram, also, NRIAG has a channel on YouTube containing lectures to amateurs and professional astronomers and geophysicists. IAU National Outreach Coordinator for Egypt, Prof. Somaya Saad is from NRIAG, also NRIAG hosts the activities of the Scientific Society of Astronomy & Space in Egypt, the society aims in the first place to carry out outreach events.

One of the special facilities of NRIAG is Kottamia Astronomical Observatory. It is located approximately 80 km away from the center of the capital "Cairo" in the direction of the Suez city, over a mountain that rises 450 meters above sea level. The Observatory was established in 1964, as an extension of Helwan observatory. It contains a 74-inch telescope, it is the largest telescope in the Arab world, the Middle East, and North Africa. A large number of scientists and researchers in the field of astronomy and physics use this telescope. It is unique in terms of its location, and its around 250 net clear nights throughout the year.

Kottamia Observatory is regarded as a small scientific city, besides the 74-inch telescope, there is a 14-inch Celestron Telescope, a number of rooms equipped for the convenience of Observers, a plant to generate electrical power (Diesel generators) to run this amount of equipment and huge electric motors for the Telescope. There are also two water reservoirs, a Garage, Kitchen, Engineering laboratories, and workshops for electricity and mechanics, a lecture hall, and a number of small telescopes used for the observatory visitors.

Every year, hundreds of astronomy lovers visit Kottamia Observatory to enjoy the clear sky and learn about astronomy. Whether they are school students or adults, the observatory staff always creates a program that suits each group. For me, I prefer to work with kids around 6 to 15 years old. At this age, kids are fascinated by the night sky and are passionate to learn more about it.

I start the visit before sunset with a tour at the observatory and the 74-inch telescope, then I took them to the Lecture hall to give them a small talk about some fundamental definitions of astronomy especially the night sky such as (celestial sphere, stars, planets, constellations, conjunction, and so on). Also, I show them that they can practice stargazing from their home, not only from the observatory, they can observe the sky from everywhere, the limit for what they can see is the pollution and lights. I show them a photo of any conjunction I took from my balcony, and motivate kids to observe these phenomena as they are the most visible events in the city's sky. I tell them the date of the next conjunction and ask them to tell their teachers or parents to help them see it. After that, I start talking about the constellations, the most exciting part for me and the most memorable part for the kids, I explain the idea of constellation & whether this image is real or not, then I show them pictures containing some stars and ask them to use their imagination to connect the stars and create a figure. At night we set our telescopes and start to observe the sky. I guide them through the different constellations, to make it easier for them to remember, I tell them the myth around each constellation, for example, the Greek mythology of Cassiopeia (the queen), Cepheus (the king), Andromeda (their daughter), Cetus (the sea monster), Perseus (who saved Andromeda). These star stories inspire kids to observe the sky and create their own stories. We spend the rest of the night laying on our backs and looking at the sky.

Over the years, the outcome of these visits has been amazing. Some of these kids choose astronomy as a graduation or science project in their school. They ask their teachers or their parents to communicate with me and inform me that they have succeeded in their project because they choose astronomy, and their teachers and colleague were fascinated by the projects, also I noticed that the thing the kids remember the most, is the stories about the sky and that they continue to observe the sky from their houses. Others even chose to pursue astronomy academically, one of these kids chose to enter the faculty of science just to study astronomy. I met her in her first year of college and she was very proud to achieve her dream, the dream that started when she visited NRIAG and saw a telescope for the first time in her life and her interests grew after she saw the wonderful night sky of Kottamia observatory.

Star Tales that Tell the Origins of their Names

Presenter: Hani Dalee, Arab Union for Astronomy & Space Sciences, Olympiad Coordinator & IAU/NOC Qatar, Qatar

Most of bright stars are well known to astronomers and amateur astronomer, but that is because they read their names in the books or to heard about them. In our talk, we will give some examples about some of these names and where they were derived from.

Poster link: https://astro4edu.org/siw/p59

If you try to look carefully into sky charts, paper or digital-based ones, you will be astonished to discover that most of these stars have Arabic origins that occurred during the Arabic-Islamic civilization, along with translations carried out later in Europe. Naming procedure has been done for the last 1000 years. Origins of these names go back to the following points: Lunar Mansions, Stars with Double Names, Arabic Constellations and Stars of Translation & Transliteration.

Al-Sufi & His Book: It was Abdul-Rahman Al-Sufi (903-986) who put the most important astronomical book in the Arab-Islamic civilization "The Book of Fixed Stars", in which he re-studied Ptolemy's Almagest and drew a figure for each constellation. He re-calculated and described the position of each star on the figure and put them in a list. Finally, he mentioned the tales of stars in the Arabian sky from where stars in modern atlases are being named until now. Arabic origins of star naming can be summarized as follows:

1. The **Lunar Mansions** are stars one or more where the moon is seen to reside every night. There are 28 mansions according to the length of the sidereal month. Of these mansions Aldebaran in Taurus, Sheratan & Botien in Aries, Al-Heka in Orion, etc.

2. Constellations in the Arabian Sky: Arabs used the stars according to their need to travel in the desert during different semesters of the year. Along with that, they wrote their own star legends, some talking about the love story between Suhail (Canopus) and Thurayya (Pleiades), another talks about Vega the eagle who tries to hunt the baby camel at the same time with the two wolves, a third is telling the tragedy of the poor's food plate, another nice one is talking about BenatNash (daughters of Nash) who are still chasing

Al-Joday (Polaris) for killing their father, and many other beautiful tales which actually write down their heroes names above in the sky, those stars we are still telling their names until now and thereafter.

3. The Arabian sky was recognized by "Names of stars in pairs". These pairs are divided into three categories:
   Star Pairs with a Single Name: They are two stars close to each other, they are given the same name with a little difference such as saying northern & southern, or brighter & fainter, etc. For example, Farkadan (Two Brightest), Diban (Two Wolves), Nasran (Two Eagles).
   Groups of Stars in Pairs: They are stars making pairs of shapes with the same name. For example, Nasakan (Two Lines), Kaffan (Two Palms), Thera'an (Two Arms).
   Individual Stars in Pairs: They are two stars, together, they are given a single name. For example, Thira' (The Arm), Niyat (The Arteries), Shaula (The Sting).

4. The Role of Translation & Transliteration in Star Naming: Arabs knew scattered stars here and there and some shapes according to their needs. They did not divide the sky like what Ptolemy had done in Almagest, therefore, when AbdulRahman Al-sufi wrote his book "Sowar Al Kawakib", he adopted Ptolemy's work. Actually, Al-sufi has done a great job when he re-drew constellation figures and described their individual stars in a list, and because the book was in Arabic, new names such as Deneb, Alpheratz, Thuban, Kaus, Rasalgethi and many other names appeared when translations and transliteration of the figures from Al-sufi's and other astronomical books took place in Europe. These new Arabic names were not known to Arabs themselves in their desert.

The total ratio of Arabic star names in the sky chart is about two thirds of the total number of names. Even if we only count the 2017 IAU Catalogue of Star Names (IAU-CSN), which is made of 240 Stars in total, 163 Arabic Stars = 67%. Because new software and mobile applications appear, more and more new names are still appearing, most of them are Arabic in origin.

Astro-cultural Tourism in Romania - Another Way of Doing Astronomy Education

Presenter: Elisabeta Ana Naghi, Education Ministry, Romania

Victor Anestin – considered to be the father of Romanian amateur astronomy: "Numbers and long equations are not the bait with which the admirers of heaven can be caught". In the last few years, we have witnessed a series of private inquiries unveiling a special kind of astronomical heritage in Romania. We group the main objects of interest for the Romanian astro-cultural tourist into the following list: 1) Astronomical ornaments to be found on old village houses, 2) Astronomical timekeeping devices, sundials, 3) Cosmological representations inside churches. The list may go on but what is most important is the fact that astro-cultural tourism can be a good starting point for astronomical education in the case of youngsters, adults and the elderly alike.

Poster link: https://astro4edu.org/siw/p60

Victor Anestin (1875-1918) – considered to be the father of Romanian amateur astronomy – once said: "Numbers and long equations are not the bait with which the admirers of heaven can be caught". In the last few years, we have witnessed a series of private inquiries unveiling a special kind of astronomical heritage in Romania. Soon this legacy may constitute the core of a special kind of tourism involving astro-cultural travels. As a dark night forms the underlying resource for celestial tourism (visiting unpolluted skies for observational or photographic astronomy), we group the main objects of interest for the Romanian astro-cultural tourist as follows:

1) Astronomical ornaments to be found on old village houses. Stylized astronomical decorations pertaining to certain celestial events such as eclipses, comets or other solar imagery have been discovered mostly in northeastern and northwestern Romania.
2) Astronomical timekeeping devices. The tourist can visit about 200 Romanian sundials, most of which are concentrated in the historical province of Transylvania: attempts to coalesce them into specific sundial trails have been made for the cities of Alba Iulia (2015) and Cluj-Napoca (2021); in the first case a flyer has been published, in the second case even a booklet.
3) Cosmological and astrological representations inside churches. A few frescoes depicting historical solar system diagrams (some geocentric, some heliocentric) can be found inside some of the picturesque, small wooden churches scattered in the area around Zalău and Baia Mare: they constitute a great starting point to the history of astronomy for the casual visitor. Finally, some churches also exhibit frescoes of the zodiac signs, though the link of religion and astrology is a complicated, albeit an interesting one. It is rather remarkable that the vast majority of these discoveries and the efforts to make them known have been undertaken by amateurs. The list may go on but what is most important is the fact that astro-cultural tourism can be a good starting point for astronomical education in the case of youngsters, adults and the elderly alike.

Discussion summary

All speakers and participants agreed that regular observations are a key ingredient in lesson plans to achieve this. These can be as simple as drawings of the phase of the moon, but there is no limit in how elaborate students can be to combine night sky observations with creative interests as well. And we concluded that for a true learning experience, students need to learn about the motion of stars with the use of a planisphere and other non-digital tools rather than a phone app that might distract them from the sky as well. Students translate what they learn into mental models and it is important to ensure that those mental models are correct as it will be difficult to change them further on.

If night sky observations with teachers and students are possible, fast moving objects such as the International Space Station can be used as natural laser pointers. Historical astronomical sites are of high interest to not only astronomers and while very fascinating in itself, can help us to interest a broader population in astronomy as well. It was pointed out that even in very light-polluted areas, the moon can be observed. Depending on the region of the world, background knowledge in the population can vary related to reasons not rooted in the school system as well, for example, if many observatories are close by or if the path of the Sun is observed for religious or cultural reasons.

Look up, learn and enjoy!

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