

Proceedings for the  
4th Shaw-IAU Workshop  
on Astronomy for Education

**Leveraging the potential of  
astronomy in formal education**

15 – 17 November, 2022



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Publications of the  
IAU Office of Astronomy for Education

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The following is a collection of summaries from the 4th Shaw-IAU workshop on Astronomy for Education held 15 – 17 November, 2022 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/4th-shaw-iau-workshop/>.

The IAU Office of Astronomy for Education (OAE) is hosted at Haus der Astronomie (HdA), managed by the Max Planck Institute for Astronomy. The OAE's mission is to support and coordinate astronomy education by astronomy researchers and educators, aimed at primary or secondary schools worldwide. HdA's hosting the OAE was made possible through the support of the German foundations Klaus Tschira Stiftung and Carl-Zeiss-Stiftung. The Shaw-IAU Workshops on Astronomy for Education are funded by the Shaw Prize Foundation.

The OAE is supported by a growing network of OAE Centers and OAE Nodes, collaborating to lead global projects developed within the network. The OAE Centers and Nodes are: the OAE Center China–Nanjing, hosted by the Beijing Planetarium (BJP); the OAE Center Cyprus, hosted by Cyprus Space Exploration Organization (CSEO); the OAE Center Egypt, hosted by the National Research Institute of Astronomy and Geophysics (NRIAG); the OAE Center India, hosted by the Inter-University Centre for Astronomy and Astrophysics (IUCAA); the OAE Center Italy, hosted by the National Institute for Astrophysics (INAF); the OAE Node Republic of Korea, hosted by the Korean Astronomical Society (KAS); OAE Node France at CY Cergy Paris University hosted by CY Cergy Paris University; and the OAE Node Nepal, hosted by the Nepal Astronomical Society (NASO).



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### 4th Shaw-IAU Workshop on Astronomy for Education

What would you need to know to be able to strengthen the role of astronomy in schools? You might want to look at how curricula are created in the first place, and you will want to profit from the experiences of those who have already been successful in including astronomy in their countries' curricula. You would likely be interested in the various roles that astronomy can play in practice, in both primary and secondary schools. You might turn to astronomy education research for answers to questions about what fosters student interest in the STEM subjects science, technology, engineering and mathematics — and since at least part of the answer appears to be that cutting-edge results, such as those involving black hole shadows or exoplanets, are of particular interest to numerous students, you might want to look into including those topics in school teaching. Last but not least, you might look for synergies between astronomy and raising awareness for one of the most pressing challenges of our time: climate change.

That, at least, were our assumptions when we considered which sessions to include in this year's Shaw-IAU Workshop, and from the feedback received so far, we seem to have hit the mark. The workshop itself was truly global, with 600 participants from more than 90 countries. We particularly salute those participants who had to make special efforts to attend, circumventing state-imposed restrictions on international communication. With these proceedings, as well as the videos and posters from the workshop that are available online, we make the various contributions available beyond the confines of the workshop itself.

Although the total count is only up to four, the Shaw-IAU Workshops have already become something of an institution. Their genesis, of course, is directly linked to the International Astronomical Union's establishment of its Office of Astronomy for Education in late 2019, hosted at Haus der Astronomie and the Max Planck Institute for Astronomy in Heidelberg, Germany, and the evolution of the Shaw-IAU Workshops has paralleled the building of the OAE as a whole. The online format started out in 2020 as a pandemic necessity. But we soon realised that the kind of online meeting the Workshops provided was a highly accessible format that would allow us to make these workshops truly global, and to set the threshold for participation as low as possible. We acknowledge that there still is a threshold – since internet access with sufficient bandwidth is required – and we will continue to look for ways of increasing accessibility even further. Perhaps the hybrid format pioneered by the OAE Center China-Nanjing this year, which combined the virtual and international Shaw-IAU Workshop with an in-person teacher workshop (as well as a nation-wide online workshop) is a model for the future?

On the part of the Office of Astronomy for Education, we hope that these proceedings will help you to make better and more effective use of astronomy in support of primary and secondary school education. It's a big universe out there — let's encourage students to explore it!

Markus Pössel  
Director, IAU Office of Astronomy for Education  
Heidelberg, December 2022





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# Organising Committees

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





# ASTRONOMY EDUCATION IN PRACTICE

# Teaching Astronomy As Its Own Subject in Secondary Schools

Session organisers: Hyunjin Shim (OAE Node Korea), Jungjoo Sohn (OAE Node Korea), Suresh Bhattarai (OAE Node Nepal), and Asmita Bhandare (OAE Heidelberg)

## SESSION OVERVIEW

In this session, we heard mostly from lecturers and teachers across different countries who are passionate about teaching “astronomy” as its own subject in secondary schools. In most countries, astronomy is not listed as an independent subject in national science curriculum standards, so teachers sometimes need to re-design the annual curriculum for their students. In addition to such a specific school-focused experience, some classroom activities were also shared. The importance of cultural integration, while designing astronomy resources and activities was highlighted. Last but not least, efforts to communicate with decision makers to emphasise the importance of astronomy in its own subject was discussed.



## TALK CONTRIBUTIONS

### Astronomy as a Beacon for Inclusive and Innovative Classrooms

Speaker: Rosa Doran, NUCLIO, NAEC Portugal

In this contribution I will summarise my ideas about how I believe that astronomy can be a beacon for inclusive and innovative classrooms.

Talk link: <https://youtu.be/9cUkmjAPFd0>

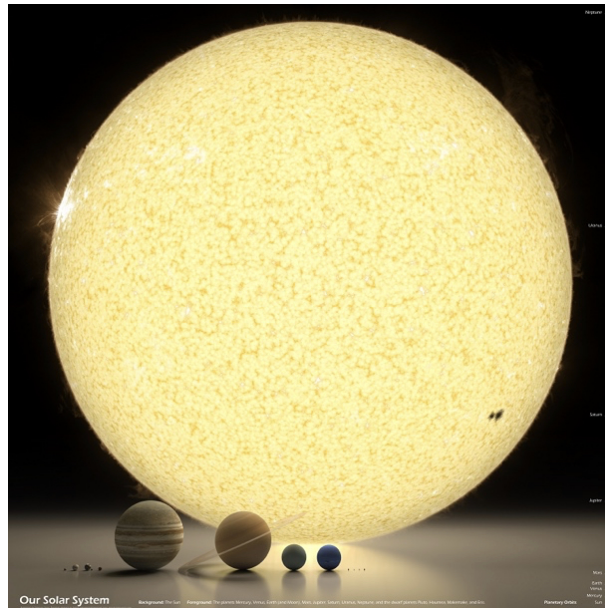


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This contribution includes what in my mind is one of the key missing aspects in humans' education – the lack of perspective of our place in the cosmos. The importance on how information is conveyed to students and how important it is to ensure that knowledge presented is unbiased, without flavours of colonisation, or in better words, ensuring a proper localisation of the information being transmitted to the younger generation.

It is often said that one image is worth a thousand words. Well, the presentation of the Solar System in text books, in animations and even in messages prepared by space agencies could not be a better example. Due to the difficulty of presenting the main bodies of the Solar System in the same image, frequently, scales are completely ignored and information that this is the case is almost always missing. It is my belief that this is one of the reasons for a complete lack of sense of scales in the Universe and how small we are in this gigantic cosmos surrounding us. This lack of awareness might as well be the cause for a general lack of humility of beings that do not know their place and importance in the vast place we inhabit.

When it is mentioned in the media that there is no Planet B, there is always a distressing feeling that humans have no idea of what that means. How many people know that we live in the habitable zone of our Solar System? That in turn lives in the habitable zone of the Milky Way, our galaxy? How many humans know that the Milky Way is just one of the galaxies of the Local Group? And that this is just a small fraction of the galaxies of the Virgo Cluster, one of the Clusters of the Laniakea Supercluster, which in turn is a small fraction of the observable Universe?.



A part of my contribution is devoted to the importance of science literacy and critical thinking to better prepare younger generations. Astronomy is by nature inter-multi-disciplinary. It can be used to introduce any topic and provides degrees of freedom for innovation and a holistic approach to education.

I highlight the importance of changing the way schools organise the facilitation of learning. Students need to find in schools a highway to their future where innovation is invading their learning experience. More than content knowledge, students should have their competence profile enriched, they have to be prepared for a future that is not yet written. If this future is to be designed with strength and beauty, it is of utmost importance to invest in preparing teachers, they are the ones that will facilitate the journey for the students for a brighter future. They are the facilitators of a winning generation.

All efforts should be put in place to empower educators to embrace technology and adapt it to their student's needs, to be capable of choosing the best methodology to trigger the hidden talents of learners.

Finally, it is very important that educators in general apply a fair, non-obstructive and inclusive approach in their classrooms. Inclusion is a big word, and implies paying attention to the needs of each individual. Inclusion is not only something for children with disabilities, it also means embracing diversity, minorities, cultural and social differences, etc. Inclusion means embracing every individual as a unique person and allowing a differentiated path to each of them with a personalised trigger to boost their talent and foster their dreams.

I urge everyone to collaborate and join hands for the mission ahead. Thousands, if not millions of teachers need our help and we should be united in a mission to reach them all. Hope to see you all somewhere around the globe, together enriching and empowering educators.



# Implementing Astronomy As Its Own Subject for Guatemalan Secondary Level Students

Speaker: Melissa Solares, American School of Guatemala, Guatemala

In Guatemala, like many other countries, astronomy is taught only as part of other school subjects like science at the primary level and physics at the secondary level. This contribution is about my experience in developing a program for teaching astronomy as its own subject in secondary school and introducing it successfully in two Guatemalan private schools. We will discuss previous research done as a way of showing the administration the importance of teaching astronomy to young students. Four years after starting this project, we can share the challenges and successful practices found along the way.



Talk link: <https://youtu.be/2lxwyeuTGrU>

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This contribution details how the first astronomy course as its own subject was introduced in two private schools in Guatemala. It outlines the process on how the program was designed based on the study of astronomy curriculum in other Latin American countries, how it was approved by the administration teams and the experience teaching astronomy for the first time to students during the virtual and hybrid education periods.

**Astronomy education in Guatemala:** Guatemala does not have astronomy as an official subject in its curriculum. Astronomy topics are included as part of the national curriculum for mandatory science courses taught during the primary education stage (ages 7 through 13), focusing on the Sun-Earth-Moon system, lunar phases, eclipses, the Solar System and cosmological theories like the Big Bang Theory and the Mayan theories for the origin of the universe.

**Astronomy program proposal for high school students:** To develop the curriculum, a state of the art program was carried out as an initial research stage on the contents and standards for astronomy secondary level courses around multiple Latin American countries that teach it as its own subject: like Chile or Uruguay. The information obtained was used as a starting point and adapted to the Guatemalan context. The result is the final version of the program that consists of five content units with the following standards:

1. Introduction: constellations and observational astronomy.  
Students locate the position of objects in the sky during the day and night in their daily lives.
2. A Brief history of the Universe: from the Big Bang to the Modern Era.  
Students relate the evidence of the evolution of the universe to their microscopic and macroscopic context.





Grade 11 and 12 students using telescopes in the 2021 astronomy cohort



Grade 11 and 12 students playing board games they created about stellar evolution.

3. The Earth, the Moon and their motions.  
Students predict changes in celestial bodies' appearance based on their geographical position and the current date.
4. The Solar System.  
Students recognise the unique environmental and astronomical characteristics of the Earth in comparison to other planets in the Solar System.
5. Interstellar Space, Stars, Galaxies and Nebulae.  
Students relate astronomical observations and available data to the study of interstellar events.

When the program was launched, in 2018, the school gave no budget to the class and students worked with material they brought from home. After three years of experience and student feedback, when it was proposed at a different school, in 2021, there was a part of the budget from the science department authorised for the class.

### **Phenomenological research: Students want to learn astronomy!**

To collect evidence on why it is important to include astronomy as its own subject, there was a phenomenological research carried out in which talks were given to high school students about different topics from math, physics and astronomy and their perspective was observed and

analysed. Focus groups were carried out afterwards and students gave out comments like:

- I have always liked astronomy because it is something we can discover/explore ourselves.
- They should teach astronomy since we are little, it should be a class that everybody has to take.

This research was later shown to the administration once the proposal was ready to be implemented, and it is one of the reasons why it was approved as a formal course.

**Astronomy education in practice:** The successful practices described correspond to working with high school students in their junior or senior year – last two years before college education – who chose astronomy as one of their elective courses. Their report cards include astronomy as its own subject. Students from this school are constantly surrounded by technology devices such as laptops, tablets and cellphones. And the use of their devices is encouraged as part of the school climate.

Digital tools include Stellarium, Zooniverse, Star in a Box and Edpuzzle. Social media was found as a powerful tool for scientific outreach; students respond positively and advance their knowledge with ease through platforms like TikTok or Instagram. Some of the projects that students have worked on include: TikToks that show the Solar System to scale; models, role-playing or comic books for learning about constellations; and board games about stellar evolution.

The creativity shown by young adults is impressive, especially if it involves creating digital content. Hands-on activities also motivate and engage them, disconnecting from devices and doing arts and craft type projects is refreshing for them.

**Recommendations:** Start by taking examples from astronomy curricula in a similar context. Administration listens to students and families: if you have their support via surveys or focus groups, there are more chances the course will be approved. Have your program proposal ready as soon as possible, so you are ready when the administration approves it. Have fun with it, take new ideas, listen to students and be flexible on how they will advance their knowledge and skills.



# Finding Space for Observational Astronomy in the Science Curriculum

Speaker: Gerri Bernard, Brisbane Girls Grammar School, Australia

In an effort to bring the awe and wonder of gorgeous astrophotography to all of our students, Brisbane Girls Grammar School has integrated observatory work into our Science curriculum. This contribution will explain how we use a series of 'Observatory Modules' in Years 7-9 to teach our students about the universe, telescopes, light, colour, CCD imaging, and image processing as we help them to generate more than 300 astrophotography images every year. The contribution will also include an introduction to our school's remote and robotic telescope facility (the Dorothy Hill Observatory), an outline of struggles that we have encountered along the way, and a plan for future outreach and development of our observational astronomy program.



Talk link: <https://youtu.be/G-8nYkD2ixo>

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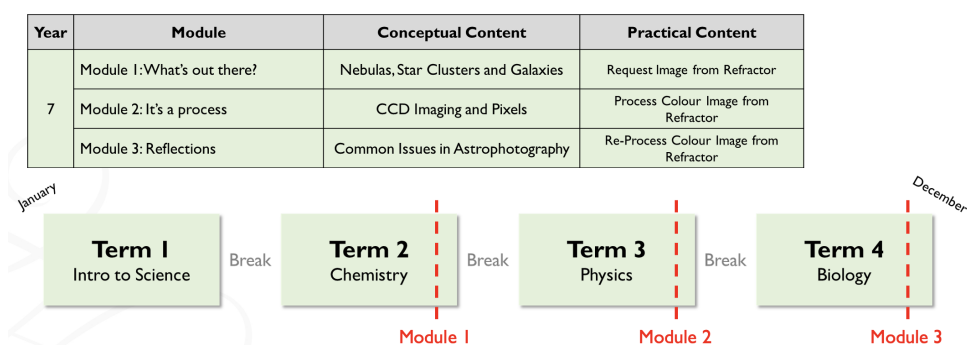
Astronomy has long been studied as part of the Brisbane Girls Grammar School (BGS) Science curriculum and is currently aligned with the Science Understanding strand of the Australian Curriculum.

The Dorothy Hill Observatory (DHO) enhances the School's commitment to astronomy, equipping Grammar girls with the knowledge and skills required to effectively undertake research using their own primary data – rather than relying on secondary data – and publish their research to support professional astronomical projects [1].

Every student at BGS uses the DHO as part of their Science curriculum in Years 7, 8, and 9. This observational astronomy program is delivered as nine 'Observatory Modules', which are presented by our classroom teachers and taught over the course of approximately three 65-minute lessons. These modules are progressive and increase in complexity from Year 7 to Year 9.

Due to the constraints of the Australian National Curriculum and our School's Science program, Observatory Modules are delivered at the end of one of our four yearly terms, in those lessons that occur after formal assessment is complete, but before the students leave for their term break. This method of implementation allows us to devote almost three weeks of science lessons per year to observational astronomy in Years 7-9 and results in the production of more than 400 astrophotography images per year from our students.

Year 7 students learn about the nature of our universe and the objects in it, with specific focus on deep sky objects such as nebulae, star clusters and galaxies. They are introduced to the functionality of the various telescopes in the Dorothy Hill Observatory and taught how the CCD



Year	Module	Conceptual Content	Practical Content
7	Module 1: What's out there?	Nebulas, Star Clusters and Galaxies	Request Image from Refractor
	Module 2: It's a process	CCD Imaging and Pixels	Process Colour Image from Refractor
	Module 3: Reflections	Common Issues in Astrophotography	Re-Process Colour Image from Refractor
8	Module 4: Going Farther	The Human Eye, How Telescopes Work	Request LRGB Image from Reflector
	Module 5: Colours of the Universe	EM Spectrum and Colour Mixing	Process LRGB Image from Reflector
	Module 6: The Universe in Motion	Dwarf Planets	Process Time Lapse of Moving Dwarf Planet/Asteroid
9	Module 7: Narrowing it Down	Emission and Spectra	Request Narrowband Image from Reflector
	Module 8: Colourful Science	Analysis of Narrowband Images	Process Narrowband Image from Reflector

telescope cameras work. Girls then choose a particular nebula, star cluster or galaxy to image using the 106 mm refracting telescope.

Year 8 students investigate how the combined functionality of the human eye and a telescope work together to produce magnified images of distant objects. They learn about the electromagnetic spectrum and the ways in which primary colours of light can be combined to make any other colour.

Girls choose a particular nebula, star cluster or galaxy to image using the 356 mm reflecting telescope, using red, green, and blue filters. They then stack and combine the images from each filter into one superior full-colour image.

Year 8 students also learn about asteroids and dwarf planets and use images from the 106 mm refracting telescope to produce a time lapse series of one of these objects moving through the sky.

Year 9 students learn about electron transition between atomic energy levels and connect this idea to the emission of light from nebulae of ionised gas. They link these concepts to atomic spectra and use this information to understand the purpose of narrowband imaging.

Girls choose a particular nebula to image using the 356 mm reflecting telescope, using  $H\alpha$ , OIII and SII narrowband filters. They then stack and combine the images from each filter into one superior full-colour Hubble palette image, which can be analysed to elucidate the presence and location of hydrogen, oxygen, and sulphur within the nebula.

This curriculum program is supported by co-curricular activities available to our students in all

year levels. Students in Years 7-10 can participate in Astronomy Club, where they will learn about various space and introductory astronomy topics. In Years 11 and 12, students can participate in the Student-Teacher Astronomy Research Symposium (STARS), in which they can use the resources of the Dorothy Hill Observatory to complete research projects involving double stars, RR Lyrae variables, or exoplanet transits. The results of these projects are then developed into research articles for publication in peer-reviewed astronomy journals [2].

## References:

1. Brisbane Girls Grammar School. (2022). Dorothy Hill Observatory. Retrieved October 15, 2022, from <https://www.bggs.qld.edu.au/about-brisbane-girls-grammar/facilities/dorothy-hill-observatory/>
2. Danalis, M., Murcott-Green, F., and Packard, K. (2022). Measuring the Position Angle and Separation of WDS 11194-0139. The Journal of Double Star Observations, 18(4), 440-445. [http://www.jdso.org/volume18/number4/Danalis\\_440\\_445.pdf](http://www.jdso.org/volume18/number4/Danalis_440_445.pdf)

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## Astronomy Education and Outreach at HUSTFZ

Speaker: Wang Qin, Huazhong University of Science and Technology, China

The middle school attached to Huazhong University of Science and Technology (HUSTFZ) is the first characteristic middle school in astronomy education in Wu Han, China. I discuss how we got this honour and how we got our ministry to listen. I also share the syllabus of my astronomy curriculum and illustrate how we run this elective course. Finally, I focus on interactive methods for astronomy education such as physics experiments, sky observations, using information technology or physical models.

Talk link: [https://youtu.be/a1\\_dZxigMQk](https://youtu.be/a1_dZxigMQk)



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HUSTFZ was rated as the first school which features astronomy in Hubei Province in May 2021, with a validity of three years, which also urges us to actively launch astronomy courses and carry out related astronomy activities.

In July 2021, students from HUSTFZ were invited by Hunan television station to participate in the program recording of observation of China's space station. It is so rare for students to go on camera. But for the school, it is the best chance to raise our profile of featuring astronomy.

Inspired by this activity, Li Bin, a physics teacher of our school used this video to explain space navigation in class. This course was selected in the excellent course of the Ministry of Education. They also organised a meeting on astronomy education for primary and secondary school teachers in central China. In September 2021, Dr. Wang participated in the design of a science fiction film in the Science and Technology Museum of Hubei Province as a scientific consultant. Based on astronomy course, Dr. Wang won a key project of Wuhan education planning. Dr. Wang organises students to watch Tiangong classroom every time. The first time was in December. After a live broadcast that day, with another physics teacher she reproduced the ground experiments in class, such as exploring angular momentum with a rotating chair and dumbbells, and explaining the surface tension of water with paper flowers. The second one was held in March 2022. These two activities on a school level were reported by well-known local newspapers.

In 2022, her student from grade 9 took part in the Hubei astronomy Olympiad preliminary and final contest, and won the second prize. At present, Dr. Wang and several teachers are working together to compile an astronomical experiment guide book, just like the book “Astronomy Lab for Kids” by Michelle Nichols. But this book focuses on hands-on experiment with clear objectives. Every step and required background, especially related to Chinese culture, will be introduced in great detail. It is of great significance for teachers who do not have an astronomy background.

There lie some difficulties for astronomy education and outreach. Astronomy is not included in entrance examinations for high school or college in China. This implies that student will not give an importance to this subject. Teachers should have a clear picture that astronomy is just an elective course before college. The QDC is not fixed, and the class hours cannot be guaranteed. If there is an important examination, or big events, you probably will not have students in your class. Teachers have to buy everything they need for the astronomy class with their own money before they get some funding or a reward with significant honour, which is extremely difficult for a teacher in basic education system. But teachers give a higher importance to their duty more than money and the world is changing.





## Project-Based Learning in the Secondary Classroom

Speaker: Shefali Mehta, Science Teacher, Princeton High School, New Jersey, USA

Project-Based Learning (PBL) has been growing in popularity in the educational setting. By introducing well-planned projects, they can serve to motivate and drive students to learn new content, collaborate in teams and be creative. However, it can be difficult to find authentic projects that capture all students' interest. This contribution introduces several projects that have been successfully implemented at the high school level that can easily be implemented into any classroom for students of all ages.



Talk link: <https://youtu.be/Tntkkg6E6cQ>

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Project-Based Learning (PBL) can appear in many different ways in the classroom. In this contribution, we focus on PBL as a teaching method in which students learn by actively engaging in real-world and personally meaningful projects. To make projects meaningful, there must be an authentic component to them – students must feel that they are relevant or that they can make an impact when proposing a solution. The benefits of authentic projects are many. When structured and planned well, students understand the purpose of learning and the content that we as teachers are sharing with them. They become engaged in the classroom lessons, having more interest and motivation to learn the content. Key factors to consider are student choice, expression, discussion, and reflection. Presenting the project components in advance of the content also helps to drive student curiosity and interest.

### Examples from the classroom:

**Top five telescopes project:** In this project, students are tasked with researching and teaching the rest of the class about two telescopes, one on the ground and one in space. In order to complete the project and understand how the telescopes work, they then begin learning content relevant to the project. We begin by learning about different telescopes and the optics involved in viewing far away objects. Students then learn about the properties of light and the technology used to analyse light. Once students have had time to learn about telescope mechanics, and their chosen telescopes, they share what they know about them. In small groups, students then discuss the different telescopes that have been researched, deciding on a list of the Top Five that had the highest impact on astronomy. Finally, students share and reflect on how their list compares with those compiled by other groups.

**The manned vs. unmanned missions debate:** Whether NASA (or other space agencies) should fund missions that are manned or unmanned can be a hot topic for students. Manned missions are great to get the public interested in space and understanding astronomy, but they are costly and have a lot of limitations due to the resources needed to support life. On the other hand,

unmanned missions are much less costly, smaller, and can withstand extreme environments since they do not need to support life. This project allows students to really discuss and debate the benefits of the two types of missions. Students first choose a mission to research, then share those with the class. After learning about some of the missions, students decide if they support NASA funding more manned or unmanned missions over the next 5-10 years. They write and deliver a short 30 second speech to share their position and evidence, then take turns defending their arguments and refuting arguments made by the other side. Depending on the time available, they can also try to convince others to accept their position. An alternative to a spoken debate is to have students write a letter to the director of NASA in support of either side.

**Solar system classification project:** Within the solar system are so many different objects, including a star, planets, moons, asteroids, comets, etc. But even within those categories, they are not all the same. Some planets are terrestrial while others are gaseous. Some moons are cratered, others are active, and even others are captured asteroids. Within the category of asteroids, there are Trojans and Centaurs, some with rings, and even some with a moon of their own. As students learn about the different categories of objects, this project gives them an opportunity to re-imagine the classification system we use and create a new one based on more than where objects happen to be and what they orbit. They can create a new system using composition, habitability, activity, etc. to group similar objects.

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## Education Programs Developed by NASE and Astronomy Education Using Python

Speaker: Won-jae Sim, Won Ju Girls' High School, Korea

Python is an advanced programming language, and various libraries have been developed to use it in many fields. In the field of astronomy, libraries such as astropy have been developed and are actually used by professional astronomers. Such libraries and FITS files are open-source, i.e., anyone can use them freely. Therefore, students are able to experience the scientists' research process directly and indirectly with interest by using them. NASE has developed various astronomical education programs. Among them, there is a program named parallel earth, which explains the causes of seasonal changes, the length and direction of shadows by latitude and longitude, and the principle of day and night very accurately using only globe, toothpicks, and clay.



Talk link: <https://youtu.be/9AI-oR0xqAQ>

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Figure 1: Teacher training using parallel earth program

The Parallel Earth program is an astronomy education program developed by Rosa. Seasonal changes and the principle of day and night occurrence are natural phenomena that can be easily understood when looking at the Earth from space. However, it is very difficult to understand these natural phenomena on Earth.

The parallel earth program has the effect of looking down at the Earth from outside of a spaceship in space. Therefore, it is easy to see the causes of seasonal changes, the causes of day and night, and the causes of different directions of shadows for each region at a glance. Rosa conducted a training program on various hands-on astronomical education programs, including the Parallel Earth program for Korean science teachers in 2020. I participated in the development of YouTube videos and educational material that introduces parallel earth programs in Korea. This activity was organised by the Korea National University of Education and Korea Astronomy & Space Science Institute.

The program was also introduced during astronomical observation training for teachers and experimental training for middle school science teachers. The parallel earth program was well received not only by elementary school teachers but also by middle and high school science teachers.

In addition, many teachers who participated in the training actively asked about parallel earth class material and necessary tools. Also, at the IAU General Assembly held in Busan in 2022, a training was conducted for teachers working in Busan. The parallel earth program has also been used in a science class. Parallel earth classes were performed with gifted students in Pyeongchang and students from Chiak High School and Wonju Girls' High School in Wonju. The students were very interested in the fact that the direction of shadows was different for each region, that they could easily understand the principles of the appearance of white nights and polar nights, and the appearance of day and night.

Python is a popular computer language. Because the structure of the language is easy and intuitive, it is used in various fields. In particular, it is used in various fields of science, and astronomers are also actively using Python in various data analysis processes. Therefore, using Python, a class on the data analysis process was conducted, which is generally difficult for students to experience. Single-session special classes using Python were conducted at Chiak High school in Wonju, Daehyeon High School in Ulsan, Sejeon high school in Jincheon and for the gifted student in Pyeongchang. During the classes, data analysis techniques using infrared

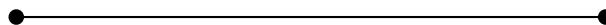


Figure 2: Astronomy class using Python

data from the Herschel space telescope and the RGB colour analysis method for continuous spectra were taught.

Python classes were also conducted in regular classes and for students' club activities. These classes lasted for a year. During this period, we performed various activities such as Hubble data analysis methods, Kepler III law, planetary orbital drawing, Voyager spacecraft's current location and solar scale, distribution of globular clusters in our galaxy, and analysis of the Andromeda galaxy, Cen A galaxy, IC434 and Barnard nebula data, and RGB color analysis of continuous spectra. After these classes, students were able to implement scientific logic courses on their own.

The classes help develop students' scientific and mathematical thinking skills and their ability to utilise a computer. Finally, they can indirectly experience the scientists' research process.



# Classroom Activity to Calculate Mars' Closest Approach to the Earth

Speaker: Lim Hosung, Gimhae Imho High School, Kyungpook National University, Korea

I introduce a classroom activity on the subject of "Mars' closest approach to Earth", designed for high school students. Earth and Mars are in opposition every two years and two months. When Mars is in opposition, the distance between Earth and Mars varies due to the characteristics of an elliptical orbit of the two planets. On August 27, 2003, the distance between Earth and Mars was about 55.5 million kilometres, which marked the date as one of the closest approach of Mars. With Mars' orbital period set to 1.8808 times that of Earth, it is possible to predict the next occasion of the closest approach based on the mathematical concept of continued fractions. The activity is designed to invoke both scientific and mathematical interest in students.



Talk link: <https://youtu.be/8FRfjIhJxSQ>

On July 27, 2018, the distance between Earth and Mars approached about 58 million km, when Mars' apparent magnitude was about -2.5 and looked brighter than Sirius, the brightest star in the night sky. The time when Mars is closest to Earth is the time when Mars is in opposition. The synodic period of Mars is 780 days, which means that Mars is placed in the position of opposition every two years and two months. However, since the orbit of Earth and Mars is elliptical, the distance to Mars at the time of opposition changes from time to time.

Figure 1 shows that the distance to Mars was 0.372AU on August 27, 2003. This was the closest in the recent 3000 years. Therefore the date is called "Mars' closest approach".

Year, Month, Day, Distance(AU)					
30 July 21	0.37458	1356 Aug. 10	0.37482	2287 Aug. 28	0.37225
235 July 17	0.37436	1403 July 31	0.37362	2366 Sept. 2	0.37239
314 July 21	0.37416	1482 Aug. 3	0.37306	2413 Aug. 21	0.37422
393 July 24	0.37421	1561 Aug. 7	0.37325	2445 Sept. 5	0.37296
472 July 28	0.37434	1640 Aug. 20	0.37347	2492 Aug. 24	0.37322
598 July 20	0.37440	1687 Aug. 9	0.37434	2524 Sept. 10	0.37364
677 July 24	0.37403	1719 Aug. 25	0.37401	2571 Aug. 30	0.37238
756 July 27	0.37369	1766 Aug. 13	0.37326	2603 Sept. 15	0.37485
835 Aug. 1	0.37391	1845 Aug. 18	0.37302	2650 Sept. 3	0.37201
914 Aug. 4	0.37459	1924 Aug. 22	0.37285	2729 Sept. 8	<b>0.37200</b>
961 July 23	0.37439	2003 Aug. 27	0.37272	2776 Aug. 27	0.37436
1040 July 27	0.37382	2050 Aug. 15	0.37405	2808 Sept. 11	0.37230
1119 July 31	0.37340	2082 Aug. 30	0.37356	2855 Aug. 31	0.37311
1198 Aug. 3	0.37346	2129 Aug. 19	0.37328	2887 Sept. 16	0.37292
1277 Aug. 7	0.37409	2161 Sept. 4	0.37459	2934 Sept. 5	0.37217
1324 July 26	0.37444	2208 Aug. 24	0.37279	2966 Sept. 20	0.37404

Figure 1: Approach of Mars to less than 0.375 AU to the Earth, years 0 to 3000 (Table 36B in More Mathematical Astronomy Morsels)

How can we predict the next occasion of the Mars' closest approach? Students can use the mathematical concept of continued fractions. Continued fraction is a way to express a number as the sum of its integer part and the reciprocal of another number. Usually the numerators of a simple continued fraction are set to 1. Mars' orbital period is 1.8808 year and Earth's orbital period is 1 year. Multiplying a factor 10000 to orbital period, we get 18808 and 10000. The least common multiple of these two is 10000 times 2351. So the next closest approach will happen after 2351 years. But a human cannot live for two thousand years. So when will be the best opportunity to see at least a very bright Mars? We can calculate dates within this century when we can see the close approach of Mars.

$$\begin{array}{rcl}
 \frac{1.8808}{1} = 1 + \frac{1}{1 + \frac{1}{7 + \frac{1}{2 + \frac{1}{1 + \frac{1}{3 + \frac{1}{8 + \dots}}}}} & \frac{15}{8} = \frac{\text{Earth rotation number}}{\text{Mars rotation number}} & \\
 & \frac{32}{17} & 2003+32=2035\text{year} \\
 & \frac{47}{25} & 2003+47=2050\text{year} \\
 & \frac{79}{42} & 2003+79=2082\text{year} \\
 & \frac{284}{151} & 
 \end{array}$$

If 1.8808 is expressed as a continued fraction, it is 15 over 8 in the third order. This means when earth orbits the Sun 15 times, Mars orbits the Sun 8 times. Therefore, the time of close approach is the year of 2018. So in this century, we can see the Mars close approach/ in 2018, 2035, 2050, and 2082. The best approximation of the Mars close approach within this century is the year of 2082.

**Resource:** Meeus, Jean (March 2003). "When Was Mars Last This Close?". *Planetarian*: 13.

## POSTER CONTRIBUTIONS

### A Pedagogical Activity to Teach the Seasons

Presenter: Oscar Rodrigues dos Santos, Federal Technological University of Paraná, Brazil

Collaborators: Michel Corci Batista (Federal Technological University of Paraná), Veridiane Cristina Matins (State Department of Education) and Taisy Fernandes Vieira (State Department of Education).

In elementary school, astronomy represents the gateway to the study of physics, especially in the final years. Through a simple experimental activity with the students' participation, the seasons of the year can be studied in different latitudes. It is easy to explain phenomena such as the midnight Sun, the apparent motion of the Sun, and the influence of the tilt of the Earth's axis using an experimental apparatus. Also, why the equatorial region has a more temperate climate, whereas the temperatures near the poles tend to be more severe.

Poster link: <https://astro4edu.org/siw/p109>



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A simple experiment built by the students can be used to investigate the seasons at different latitudes. With the help of an experimental apparatus, phenomena such as the midnight Sun, the apparent motion of the Sun, and the influence of the tilt of the Earth's axis can be easily explained. In addition, the equatorial region has a warmer climate, while temperatures near the poles are more severe.

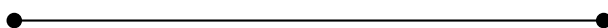
In order to contribute to the teaching of astronomy in elementary education, this work aimed at developing an auxiliary material for science and physics teachers, using simple but correct language and easy to consult, and at evaluating its pedagogical potential. The first has a quantitative approach, for which an experiment was conducted comparing the performance of elementary school students on an assessment instrument consisting of 29 questions about physics and astronomy, before and after the introduction of the interdisciplinary notebook for practical activities in astronomy. The second phase has a qualitative approach of descriptive type, for which we used a field diary prepared by the researching teacher during the implementation of the activities, as well as the documents prepared by the students as a data collection tool.

The results of the first phase were organised using the paired parametric t-test. The choice of this test accounts for the intra-individual dependence of the observations. In general, our results



show a build-up of practical and dynamic thinking that motivates students to be interested in astronomy and, most importantly, a change in the attitude of the teacher-researcher in front of the classroom. Physics, geography, and mathematics are interconnected disciplines, and a practice-based approach to learning astronomy can improve their understanding.

The subject's participation and the students resuming of their role as an active person can improve their oral and written skills, and the possibility of appreciating astronomy in their daily lives. The activity, when presented to students, generates satisfaction from all. Students are positively surprised as they understand the fact that the inclination of the Earth's axis causes incidence in different ways in different parts of the surface, causing different phenomena, and the teachers are satisfied for being able to facilitate learning. We hope that this material can be used by other teachers, with minor adaptations, to provide quality astronomy content. We believe that the implemented material has a great pedagogical potential, with a motivational and reflective character.



## Developing Self-Constructed Visual Instructional Material for the Lesson about Comets

Presenter: Paul Anton Mahinay, Pasig Catholic College, Philippines

Education plays a vital role in the development of society. Quality education can be achieved through creative and effective instructional materials. Therefore, this study aimed to increase the achievement of learning competencies in comets through self-constructed visual instructional material. Descriptive method of research was employed wherein standardised diagnostic and achievement test was administered to 437 grade 8 students of Pasig Catholic College and the self-constructed visual instructional material was used in the discussion of the lessons.



Poster link: <https://astro4edu.org/siw/p111>

The K to 12 science curriculum of the Philippines provides competencies that aim for the Filipino learners to demonstrate understanding of key science concepts and application of scientific-inquiry based skills. In this curriculum, topic about comets is one of the astronomical concepts taught in secondary science. According to the DOST Science Education institute, different efforts were made to improve the science education in the Philippines and the result of their research shows the quality of teachers and learning interactions provided by the teachers affects the learning of students. In line with this, both public and private education institutions conduct



The researcher presenting his self-constructed visual instructional material.

several assessments or tests to identify the achievement of the learners, standard level of learning competencies and factors affecting the student's achievement. Thus, Pasig Catholic College together with Excelandia I.T. Services provided a standardised assessment that helped the teachers to identify the level of learning competencies achieved by the learners.

On the other hand, use of instructional materials augments the learning process of the students, making the discussion more effective (Socias 1987 & Aquino 1988). Developing instructional material is an avenue to improve the learning process especially for science concepts. Earth and space science is one of the fields of science in the K12 curriculum, and this field must be taught with visual materials, specifically the topic about comets.

To enhance the learning process of teaching comets at the secondary level, the researcher created a comet made of crumpled paper and foil. Magnets were attached to it so that it could be placed on a 18x20 canvas to manipulate it and demonstrate the movement of the comet. Fairy lights were also used to represent stars in space. A QR code generator and HP Reveal applications were also used to give additional information and to make the material more interactive.

First, the researcher painted a rocket that served as the image target and infographics about comets from google were used to create an augmented image. The researcher used HP Reveal applications for this material. On the other hand, a QR code generator was used to incorporate the story of Rosetta and Philae mission.

To check the self-constructed visual instructional material for the lesson in comets, articulation of grade 8 teachers was done, and it was used in the discussion of the lesson in grade 8 after the diagnostic test and before the achievement test administered. The researcher used a standardised diagnostic and achievement test provided by Excelandia I.T. Services. It was constructed in a way that determines and measures the standards level of learning competencies. It utilised scales namely (0%-29%) starting (30%- 59%) progressing (60%-79%) competent (80%-89%) mastering (90%-100%) outstanding.

The results show an improvement on the standards level of learning competencies of grade 8 students when it comes to the lesson of comets after the self-constructed visual instructional materials were used. It indicates that teacher preparation and creativity in the usage of self-constructed visual learning materials can help in improving the achievement of the learning competencies.

Learning Competencies in Comets	Diagnostic		Achievement	
	Correct % & standards level		Correct % & standards level	
Compare and contrast comets, meteors and asteroids	54%	Progressing	62%	Progressing
Predict the appearance of comets based on recorded data of previous appearances	17%	Starting	21%	Starting

Table 1. Grade 8 Science Diagnostic and Achievement Tests - Comparative Results

### Resources:

- Bukoye, Rosaline O. (2019). Utilization of Instruction Materials as Tools for Effective Academic Performance of Students: Implications for Counselling. Department of Counselling Psychology, Niger State, Nigeria.
- Comets- Teaching Tips. Retrieved from [history.amazingspace.org](http://history.amazingspace.org) [Accessed December 13, 2019]
- Dauber, P. & Muller, R. (1996). The Three Big Bangs. Massachusetts, USA. Addison-Wesley Publishing Company.
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- Diagnostic- Achievement Test in Science Excelandia I.T. Services
- Dizon, M., Garcia, R., Laurente, J. & Lim, A. (2015). Science for The 21st Century Learner. Makati City: DIWA Learning Systems.
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- Volume 9 – Number 14 June 2018, pg. 129-147, Synthesis Research Journal
- Volume 39 2017, pg. 11-16, Philippine Physics Journal





# Three High School Teachers Bring Subaru Telescope's Big Data to Their Classrooms

Presenter: Kumiko Usuda-Sato, Subaru Telescope, National Astronomical Observatory of Japan, USA

Collaborators: Tadashi Hara (Toyo University, Japan), Tamiki Togashi (Saitama Prefectural Kasukabe High School, Japan), Yuichiro Hiratsuka (Saitama Prefectural Yorii-Johoku High School, Japan), and Akihiko Tomita (Wakayama University, Japan).

The Subaru Telescope is a large optical-infrared telescope near the summit of Maunakea, Hawaii. The telescope conducted an extensive survey called the Hyper Suprime-Cam (HSC) Subaru Strategic Program using the ultrawide-field imaging camera HSC. The big survey data is partially open to the public, and anyone can freely explore the vast cosmic images on the hscMap website. The three high-school science teachers (Hara, Togashi, and Hiratsuka) in Japan developed educational material using hscMap to bring one of the world's highest-quality astronomical data to their classrooms, including at a University. According to a questionnaire after Hara's lecture at a teacher-training course at Toyo University, many trainee students were interested in using hscMap when they became teachers.



Poster link: <https://astro4edu.org/siw/p112>

The Subaru Telescope is an 8.2-meter optical-infrared telescope near the summit of Maunakea on the Island of Hawaii. The telescope conducted an extensive survey called the Hyper Suprime-Cam (HSC) Subaru Strategic Program using the ultrawide-field imaging camera HSC. The extensive survey data is partially open to the public, and anyone can freely explore the vast cosmic images on the hscMap website (<http://hscmap.mtk.nao.ac.jp>, [http://prc.nao.ac.jp/citizen-science/hscv/index\\_e.html](http://prc.nao.ac.jp/citizen-science/hscv/index_e.html)).

Since May 2021, three earth science high school teachers (Hara, Togashi, and Hiratsuka) and two astronomers (Usuda-Sato and Tomita) have had monthly online meetings and developed teaching material using hscMap. (note: Hara is a retired teacher at Saitama Prefectural Tyooka High School and now teaching at Toyo University). The three teachers shared their ideas at the online meetings, developed the prototype materials, tried them in their classrooms and/or after-school enrichment programs, and brushed them up.

As shown in Table 1, six resources were developed with different themes, duration, and levels combined with the H0 common header. The title prefix "A" means easy or moderate level, and "C" means a difficult level for calculation activities; students are required to calculate the size or distance of celestial bodies with a simple trigonometric function. Educators can tailor their teaching content by combining some of them according to the class time and students' level.

Title	Duration	Level	Calculation	Themes	Created by
H0-hscMap operation	10 - 15 min	easy	-	How to operate hscMap	Hara
A1-Hubble Classification	10 - 20 min	moderate	-	Diversity and interaction of galaxies	Hara
A2-Distant galaxies	15 - 20 min	moderate	-	Apparent size, brightness, and color (Hubble-Lemaître law)	Hara
A3-Fuzzy objects in the Universe	40 min	easy	-	Different kinds of celestial bodies	Hiratsuka
C1-Angular distance of a galaxy	20 - 30 min	difficult	required	Estimation of the size of a galaxy and galaxy cluster	Hara
C2-Size of a galaxy cluster	20 - 30 min	difficult	required	Estimation of the distance of a galaxy cluster	Hara
C3-Number of galaxies in the Universe	40 min	difficult	required	Estimation of the number of galaxies in the entire Universe	Togashi

Table 1: List of teaching resources

They must start from H0 to let students get used to the hscMap operation. In some resources like A2 and A3, students are required to observe the colour of celestial objects. A colour template is included in the student's worksheet to eliminate the colour difference between monitors.

The teaching material (worksheets for students and educator guidelines) listed above are available online in Japanese with free access for teachers and educators via <https://drive.google.com/drive/folders/1ENAsT7T3B3Dv9wVoCUMxJkoo2di0a3I3>.



# A Method to Carry Out Astronomy Education Based on Curriculum Standards

Using the construction of school-based astronomy curriculum by Jiangsu Tianyi High School Astronomical Society as an example

Presenter: Xinrong Shen, Jiangsu Tianyi High School, Jiangsu Autonomous Learning Institute, Wuxi, Jiangsu, China and Zhuoyan Xie, Jiangsu Tianyi High School, Wuxi, Jiangsu, China

In the 2017 edition of “General Senior Middle School Geography Curriculum Standards” in mainland China, “Astronomy Fundamentals” is, for the first time, listed as an independent elective module, which lays the foundation for the development of high school astronomy education from the national curriculum standards. As a provincial-level “excellent middle school astronomical society”, Tianyi Astronomical Society has systematically carried out the construction of school-based middle school astronomy curriculum based on national curriculum standards. It has developed rich curriculum of three types - popularisation, academic, and research. It has carried out a series of extraordinary research independently or in cooperation with world-leading institutions, and achieved fruitful results.

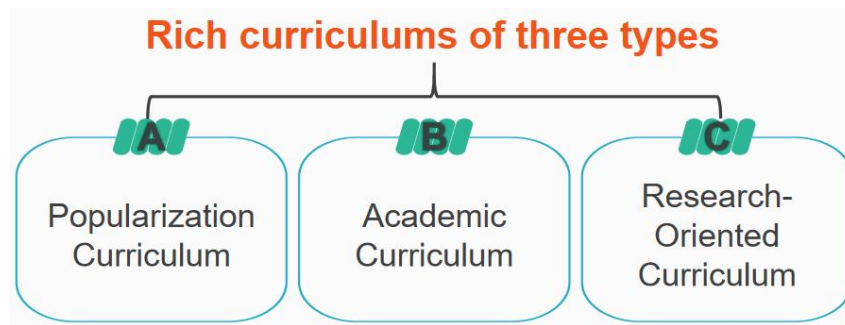
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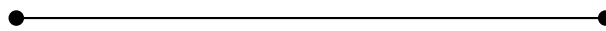
The curriculum standard requires that students should be guided to develop a correct understanding of astronomical phenomena, stimulate their interest in exploring the universe and establish a scientific outlook for the universe by learning modules such as astronomical observation, solar system and Earth-Moon system, Sun and stellar world, Milky Way and the universe. Based on Curriculum Standards, Jiangsu Tianyi High School Astronomical Society has developed a rich curriculum of three types - popularisation, academic, and research.

1. Popularisation Curriculum: Based on the typical characteristics of each discipline, taking activities and personal involvements as the fundamental form, and students' interests cultivation as the prime objective, it targets the whole campus by carrying out popular science lectures and events.
2. Academic Curriculum: Based on the core info of each discipline, taking the intensive training as the main form and solid achievement in both knowledge and skills as the prime objective, it targets the students' associations by carrying out theoretical studies and observational practice.



3. Research-Oriented Curriculum: The prime objective is to develop research skills by using research projects in each sub-discipline and targets scientific teams and individuals.

Tianyi Astronomical Society has carried out a series of extraordinary research independently and in cooperation with world-leading institutions, and achieved fruitful results. In recent years, students have discovered 20 near-earth objects, won more than 10 medals at the International and the National Astronomy Olympiad, and won more than 100 medals at various scientific and technological competitions. students have published more than 10 papers in academic journals. A group of students entered top universities such as Peking University, Nanjing University, Princeton University, Cornell University, etc. to continue their education in astronomy.



## Astronomy in Secondary Schools: Curriculum to Establishment

Presenter: Prasad Rathod, Syzygy Outreach Space Club, India

Collaborators: Vriddhi Gupta, Priyanka Lakariya, Abrar Sayyed, and Jonack Abdullah Al Mahamud.

Cognitive evolution of the brain maps our curriculum. Establishment of labs & utilisation of existing facilities is stressed. Survey of schools with/without astronomy courses forms our database. A learning model is proposed which utilises pre-existing subjects to promote astronomy. A demographic study was conducted to gather information about institutions having astronomical setups to be used as Nodal centres. To remove the fear of future uncertainty, inclusion of space startups will be done to provide internships. Research focuses on creating ecosystems within Nodal centres of under-graduates, post-graduates & PhD students pursuing astronomy to improve the syllabus and help students with their projects. MoUs schemes are devised to fulfil gaps with universities globally.



Poster link: <https://astro4edu.org/siw/p114>

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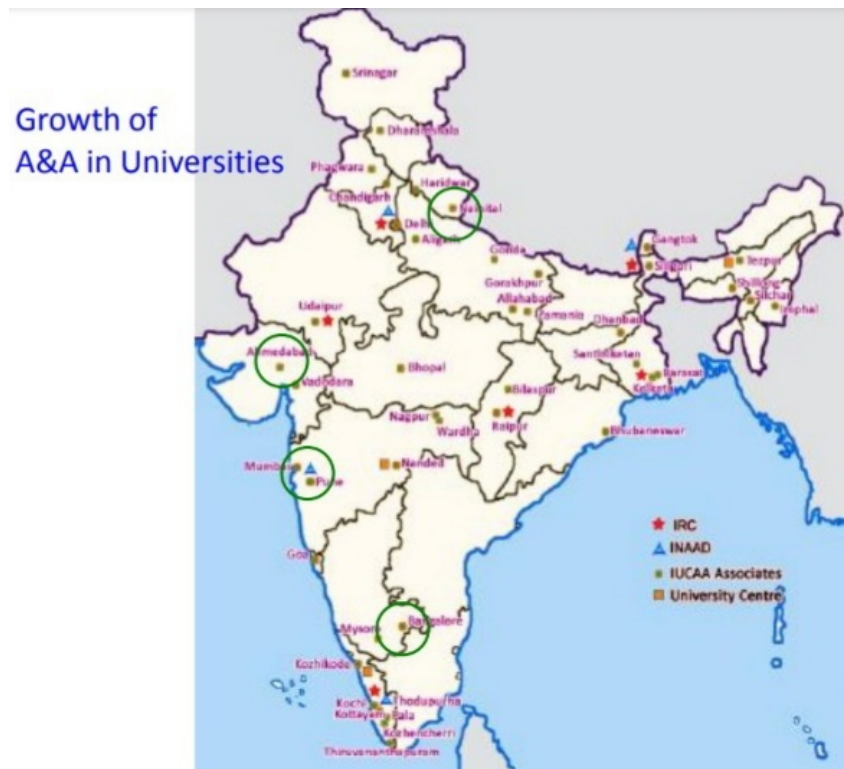


Figure 1: Demographics of Universities under Nodal Center Mapping

In our research, we study the cognitive evolution of the brain during secondary school to embark on astronomical learning. Our research focuses on development of teacher's training, developing curriculum, establishment of labs and utilisation of existing facilities.

Backed with survey of schools with/without astronomy courses, we have our own database collected for developing astronomy as a subject. Spectrum of astronomy is analysed by finding its common links with subjects such as physics, mathematics, chemistry, and geography. A tied learning model is proposed for utilising maximum support of pre-existing subjects to promote astronomy.

A demographic study was conducted, which gathered information about already existing institutions having astronomical setups. These institutions were plotted on the map of India and a density analysis was done. Research suggests use of these institutions in multiple phases to establish astronomical board of studies having them as nodal centers. These will facilitate schools by providing them instrumental assistance for cost-effectiveness. To remove the fear of job and future uncertainty plus providing application-based insights, inclusion of space startups will be done to provide meaningful opportunities to students in the form of internships.

Research is based on creation of ecosystem having under-graduates, post-graduates & PhD students pursuing astronomy in Nodal centres. They will have access to a repository of thesis/projects by these students. Projects can be displayed/tested in schools to help schools students have a better overview. Gaps in educational setup come when things revolve around infrastructure. Heavy use of physics, chemistry and other labs is incorporated in this research.

Additionally, MoUs and settlement schemes are devised in this research to fulfil gaps with universities around the world. Special focus on monetisation of infrastructure is done to motivate schools to undergo economic reforms. The syllabus is designed to mostly cover important cognitive skills. Coupled learning is an additional feature where astronomy is integrated with main-stream subjects. The syllabus has an extensive goal of helping students perform well at International Olympiads and develop a scientific temper.

Implementation of syllabus is so economical that none of the schools will feel the burden at any stage because of the use of cost-effective learning tools. Implementation of the whole subject is planned in such a way that it uplifts economy and creates potential hot-spots for future expansion and growth. Phase-based approach for 7 years from start of initiation of this subject is devised for smooth introduction and establishment. Methods for assuring quality delivery of this subject have also been discussed, which include mandatory procedures to be followed by institutions. This mandatory clause also includes a portion that enables personal growth of teachers in this subject, which never lets the dynamic nature of this subject fade away.

## DISCUSSION SUMMARY

The discussion focused on curriculum development, hands-on astronomy activities and incorporating existing teaching-learning resources at elementary-school, middle-school and high-school.

Astronomy educators from across the globe shared their experiences and different cultural perspectives on working with students and teachers and highlighted different issues faced, while implementing astronomy as its own subject in their local schools. The differences in introducing astronomy education in public/government versus private schools was also pointed out.

Project-based learning (PBL) was seen to be a useful way to introduce hands-on astronomy activities. Some panellists also pointed at some existing resources such as NASE courses and the advantage of student-centric classrooms.

Participants discussed faster processes of creating different projects, especially for those astronomy educators who volunteer extra time to develop these outside of their regular jobs. The lack of trained teachers has always been a major hurdle in promoting astronomy education and hence the need and importance of teacher training programs was voiced, either in-person or as a virtual workshop.





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