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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Asmita Bhandare, Eduardo Penteado, Rebecca Sanderson, Tshiamiso Makwela, Niall Deacon, Moupiya Maji, Emmanuel Rollinde, Francesca Cresta, and Aniket Sule.

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).

Foreword

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

Contents

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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 and Curriculum

How to Develop an Astronomy Curriculum

Session organisers: Tshiamiso Makwela (OAE Heidelberg), Markus Pössel (OAE Heidelberg), Li Jian (OAE Center China, Nanjing), Farseem Mohammedy (NAEC, Bangladesh), and Li Peng (OAE Center China, Nanjing)

Session overview

In this session, we will hear from astronomers, lecturers, and teachers on their experiences and work in developing an astronomy curriculum in their own country. In most parts of the world, astronomy is not included as a subject of its own in primary and secondary schools, it is either a part of other subjects such as physics, geography, or natural sciences. Astronomy continues to be a growing field of study that captures students' interests from an early age, as such, the development of an astronomy curriculum is important to equip learners with knowledge and skills that would improve their scientific literacy.

Our speakers come from different parts of the world, with diverse backgrounds and experiences, their passion for education and science, has seen them develop astronomy curricula in their specific locations. For teachers, developing the curriculum aims at improving students' knowledge and for these young students to use the skills that they gain in STEAM fields to become successful later in life, as they do not only route learn the theory but apply them in the future. Meanwhile, for astronomers and practitioners, being part of the development of the curriculum aims to ensure the transfer of content knowledge, teaching materials, and accuracy of scientific events.

For most parts, the development of the astronomy curriculum is done through a collaboration with a teacher, an astronomer/scientist, and a practitioner (a person who works in astronomy either as a communicator, curator, or amateur astronomer). This collaboration covers the basics of what is needed such as the education goals from the education standards, the layout of concepts as it is done in textbooks as well as 'the know how to' teach.

“Starting the Adventure of Learning About the Universe” a New Astronomy Curriculum for Primary level in Romania Aimed at Developing Integrated STEAM Skills

Speakers: Elisabeta Ana Naghi, ESERO, Romanian National Committee for Astronomy and Felicia Elena Calmuc, English teacher, Romania

The reconfiguration of the learning landscape, where the classroom must become the centre of innovation, the personal needs of students must be prioritised, technology must play a fundamental role, and where students must be challenged to create the future is imperative for 21st century education. “Starting the adventure of learning about the universe” is a new optional school subject for the primary level in Romania, it is part of the national curriculum and its main aim is to develop STEAM competences through integrated, inter- and trans-disciplinary approaches, key competences, as well as transversal competences. The learning activities are structured by taking into account 3 main topics: exploring the Solar System, travelling to and travellers in Outer Space and jobs of the future.

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

“Starting the adventure of learning about the universe” is an astronomy curriculum at school decision (for school subjects which are not part of the obligatory curriculum, but can be taught in schools if approved by the Ministry of Education) designed for primary level students from Romania (6 to 10-11 years old) that has been recently approved by the Romanian Ministry of Education. Therefore, all primary level teachers will have the possibility of implementing it in the classroom in the near future or can select contents to be used for school disciplines that are part of the national curriculum during the present school year. In Romania, the primary level covers 5 years for students aged 6-11 – preparatory grade, 1st, 2nd, 3rd, and 4th grades.

The process of creating this curriculum based on astronomy and space science concepts started from the idea that the 21st century school has to be more like an “Innovation center” aimed at developing new integrated STEAM skills necessary for young students to become successful teenagers and, later on, adults. In a world where nothing is possible without technology anymore, students should be offered a proper educational context that enables them not only to memorise the past, but also create the future.

From the very beginning, it was obvious that the creation of this astronomy curriculum had to involve specialists to cover two main areas: the scientific part, coordinated by the Romanian

NAEC, Elisabeta Ana Naghi and the teaching part, coordinated by a primary teacher, Maria Borsan. It is important to mention that the working group members had previously involved their students in other common astronomy projects, such as "Women in Space" by the IAU or "World Space Week". That is why the team cohesion was not a problem, as its members knew each other and had already identified common educational issues that were to be solved by this new curriculum. Finally, six primary level and three secondary level teachers formed the working group to cover the two parts mentioned above: the scientific notions (secondary level teachers) and the teaching strategies, techniques and methods (primary level teachers). The number of teachers involved is not random, as the final form of the curriculum contains three main topics or chapters, each one developed by two primary teachers and one secondary teacher, namely *Exploring the Solar System*, *Voyages and Voyagers in the Cosmic Space* and *Jobs of the Future*.

Each of these three main chapters contain teaching activities based on concepts that aim at developing one general skill/chapter with three subsequent sets of specific skills for each general skill. All these skills are in accordance with the two school levels of the primary students, namely preparatory grade, 1st and 2nd grades (level of acquisitions) and 3rd and 4th grades (level of development and applications). The activities are designed to respect the principle of continuity and development within each school level, as well as from one level to another.

The educational resources, as well as the teaching strategies, techniques and methods were chosen with a view to making the study of astronomy and space sciences both attractive and useful for the young learners who represent the target group of this curriculum. Moreover, in the context of a society requiring integrated skills, the activities were also conceived by taking into account the modern concept of STEAM teaching and learning.

The working group also considered that STEAM activities are very appropriate for this curriculum, as there are two main options for its implementation. In the Romanian educational system, apart the main curriculum which is mandatory, schools can implement other approved curricula for a certain number of classes/week, depending on the grade and the school level. As this astronomy curriculum is approved by the Ministry of Education, it can be implemented by any school from Romania at primary level, as a distinct school subject for two years (one year for each school level already mentioned). However, there is also another possibility, namely some activities can be implemented during the classes of the mandatory school subjects for primary level (Math, Arts, Sciences, English, so on and so forth), depending on the educational needs each primary teacher identifies for their students. We consider this aspect to be a real advantage for its implementation, which is, in fact, the most important issue when it comes to such curricula.

Nowadays, it is very important for young learners to get familiar with new educational contexts that show them both the opportunities and the limitations of science. Therefore, they will better understand the world around them and later on, due to this understanding, they will be able to deal with new challenges related to finding solutions to the problems of the society they live in. These are the kind of citizens we hope our children will become one day, namely citizens prepared for the future.

Taking into account the latest discoveries in the field of space travelling, it is obvious that human society will become interplanetary at some point, in a not very far future. In this context, our curriculum also provides educational resources developed by the European Bureau of Resources for Space Education (ESERO) of the Romanian Space Agency (ROSA) based on a protocol between ROSA and the Romanian Ministry of Education designed to support astronomy education in our country.

Primary teachers who are willing to implement this curriculum will also have the opportunity to take part in training courses officially organised all over the country. At present, the Romanian NAEC is creating a database with trainers who can provide these courses. Afterwards, primary teachers will get the necessary information from the local school inspectorates to attend them. Our children will have the opportunity to explore the space themselves, it is a certainty. Our duty as teachers is to prepare them for this future and we hope this astronomy curriculum for primary level represents "Starting the adventure of learning about the universe".

Primary School Astronomy Lessons – 10 Fun and Effective Strategies

Speaker: Zhu Geya, Astronomy teacher at Zhongguancun No. 2 Primary School, Haidian District, Beijing, China

Primary school astronomy education is different from the systematic astronomy curriculum in secondary schools and universities. The astronomy knowledge itself is not necessarily the most important focus in the class, and the teaching methods and skills often account for a large proportion. In addition, the main goal of primary school astronomy education should be stimulating students' interest, and help children form the habit of "looking up at the sky". This report summarises the author's nearly 20 years experiences in primary school teaching into 10 effective teaching strategies that may inspire the readers.

Talk link: https://youtu.be/eBKZkw25OPM

This summary describes how to offer interest-oriented astronomy courses in Primary K3. Combined with nearly 20 years of teaching practice, 10 interesting and effective activity strategies have been developed to mobilise children's imagination in the classroom, spark their curiosity about the universe, and stimulate their curiosity for knowledge. For example, ask children to give themselves "astronomical names" and ask them to remember difficult astronomical terms; By issuing "Galaxy Coins", children can collect "astronomical coins" with astronomical pictures printed on them, and exchange them for astronomy books, movie tickets, game opportunities, etc. In some courses, we guide students to make "Secret Files of Mars", "Gas Mask of Venus", “Model of the Sun Structure”, and also design games such as “Celestial Collision” and “Little King Tournament”, and even use stage plays in astronomy teaching. We found that in the design of the primary school astronomy curriculum, through a variety of interesting teaching methods, it is more important to guide children to play and love astronomy than just to impart knowledge.

10 Effective Strategy Activities:

Strategy 1: Carefully design and build astronomy classrooms

Strategy 2: Give each person an astronomical name

Strategy 3: Develop "Galaxy Coin" in class

Strategy 4: Design "Astro Game"

Strategy 5: Carry out a variety of hands-on activities

Strategy 6: Combine mythology, starry sky software, and develop constellation seals to explain the four seasons of the starry sky

Strategy 7: Develop starry sky stage plays

Strategy 8: Invite astronomy lecturers into astronomy classes

Strategy 9: Introduce remote observatory technology into the classroom and enrich classroom teaching

Strategy 10: Extend the astronomy classroom to the outdoors – to use bigger space

New Space Education

Speaker: Ayelet Weizman, Kibbutzim College of Education, Technology and the Arts, Israel

The "New-Space" era provides many opportunities for widening the meaning of astronomy education. In this contribution, my perspective and experience as a Space Educator are described, and some examples, from a M.Ed. in EdTech track centered on Innovation and Space Education, located in a College for Education in Israel are presented. The participants in this track are mainly K-12 teachers in various subject matters. Our vision is that space can be used as a context, inspiration, and example for teaching any subject matter, for the integration of innovative technologies in teaching, and for teaching 21st Century skills, like problem solving, collaborative-learning, critical thinking and agility. I have discussed some students' action-research examples of learning-units that they developed for their own students.

Talk link: https://youtu.be/R4tAiQV3mlI

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The "New-Space" era provides many opportunities for widening the meaning of astronomy education. It is no longer restricted for outstanding individuals but becomes relevant for a wider audience. The "players" in the space sector are no longer superpowers, but also private companies, associations, and entrepreneurs. The people who get to experience a space journey are not only professional astronauts, but also ordinary people, space-tourists, with varied ages, professions, ethnicities. When teaching and learning about space, we should add many aspects that were not emphasised before, like Space-Entrepreneurship, Space-Design, Space-Laws, Space-Psychology, and Space Tourism. Therefore, I suggest replacing the term "Astronomy Education" with "Space Education", conveying the message that space is related to everyone, and anyone can be part of it.

In terms of curriculum design, I see Space Education as a spiral cross-curricular topic, intertwined with technology. The goal of the educational system is to prepare students to cope with future challenges. Space can be seen as a context for such challenges, and as the source of many examples of how to use technology to overcome challenges.

Many countries have adopted the concepts of Computational Thinking together with Digital Literacy as part of their curriculum. In my view space can serve as the perfect context for teaching these concepts. In addition, Space Missions provide wonderful examples for engaging in constructivist-based pedagogies, like PBL (Problem- or Project- Based Learning), IBL (Inquiry Based Learning), DBL (Design Based Learning) etc.

This approach is applied at Kibbutzim College of Education in Israel, as the rationale for a M.Ed. in EdTech two-years track called "Innovation, Space and Robotics". The participants in this track are mainly K-12 teachers and informal educators, graduated in various disciplines, and teaching

Elementary School			
Grade	Topic	Skills	Technology
K-2	Basic space concepts	Reading Digital Literacy	Digital games
4-5	The Solar System	Problem Solving, Computational Thinking	Robots (Thymio)
5-6	Earth & Planetary Surface formations	Problem Solving, Computational Thinking	Robots (EV3)
Middle School			
Grade	Topic	Skills	Technology
6-8	Analog Space Inquiry interdisciplinary topics in 3 main aspects: Environmental, Human, Technology	Inquiry skills Teamwork Problem Solving	Sensors Robots

various grade levels. Our vision is that Space can be used as a context, inspiration, and example for teaching any subject matter, for the integration of innovative technologies in teaching, and for teaching 21st Century skills, like problem solving, collaborative-learning, critical thinking, and agility.

For their final project, students in this track engage in action research to study an educational problem from their own experience. The studies are related to either space, robotics, or other aspects of innovative technology in education.

As a result of two years of studies, a partial outline for a New-Space Curriculum shown in Table 1 has emerged.

Some findings from students' action research:

- Young students can understand concepts about motions in the Sun-Earth-Moon system.
- 5th grade students' engagement and motivation in learning increased through participation in a unit based on space & robots.
- Teachers who had no background in space and computing designed effective units after studying computational thinking in space contexts.

Conclusions: "New Space" brings new challenges and opportunities that require a new approach to curriculum development. I suggest including space as a context intertwined with technology as a cross-curricular topic. Our students' action research studies indicate that through application of innovative pedagogical approaches (like PBL, DBL, IBL etc.) students will develop competences and skills to cope with future challenges.

The Role of OAE Center Egypt in Astronomy Education and Developing Curricula for the Pre-University

Speaker: Somaya Saad, National Research Institute of Astronomy and Geophysics, Egypt

The education of astronomy in the pre-university levels represents one of the most important challenges in our societies where astronomy has not been linked with basic sciences as required or appropriately. By evaluating the curricula of astronomy in pre-university levels, we found a large gap between these curricula and scientific facts and recent discoveries about the universe. With the beginning of work at the Astronomy Teaching Center in Egypt and Arabic-speaking countries the work has been done to evaluate science curricula for early stages of education, the missing topics were collected and work in parallel to provide complementary scientific materials.

Talk link: `https://youtu.be/Nb9tEgu9isA`

The OAE Center in Egypt hosted at the National Research Institute of Astronomy and Geophysics NRIAG, Helwan, Cairo Egypt. NRIAG is considered a beacon of astronomy education, awareness and outreach in Egypt, North Africa and the Arab region. NRIAG plays an essential role in this respect on an academic level through its different facilities of expert staff and resources.

The OAE Center Egypt contributes and supports the education of astronomy at early stages, by working in parallel on five axes:

1. Curriculum development: cooperation with the Ministry of Education and search together with experts on ways of cooperation to contribute to the development of curricula.

2. Organising training courses and workshops: to qualify teachers for teaching astronomy in a practical way.

3. Producing educational materials: writing Arabic booklets and books to simplify the teaching of astronomy, and designing models to explain modern astronomical topics in a simplified manner.

4. Translating educational materials: as language is considered a barrier that prevents many teachers and students from deepening their knowledge of astronomy and making it available to them.

5. Strengthening the role of the center at the regional level in the Arabic speaking countries through the regular interaction of the OAE Center Egypt with the NAEC teams in the Arabic speaking countries.

OAE Center Egypt goes through these axes via five steps.

1. We worked on evaluation of the astronomical topics in the curricula from ages 6-12, 13-15 and 16-18. In summary we found missing knowledge about basics and recent developments and discoveries about the cosmos.

2. We produced a number of simplified books about some astronomical topics, designed some astronomical models and developed a number of astronomical cards.

3. We organised the training courses and workshops for students and teachers.

4. We introduced astronomical concepts following different astronomical phenomena.

5. In the Arabic region we organised a workshop with NAECs and NOCs of Arabic countries to discuss the challenges and ways for cooperation in developing astronomy education at the early stages of education.

Fulldome Curriculum of Astronomy Lessons for Primary School Students in the Dome Theater of China Science and Technology Museum

Speaker: Zhao Ranzi, Technology teacher at the China Science and Technology Museum, China

China Science and Technology Museum has a 30-meter dome with a digital & optical astronomical demonstration system. Since 2018, we have developed 10 lessons on different topics for primary school students and families. Each lesson lasts about an hour. Students can not only enjoy the starry sky at any time and place, special celestial phenomena such as eclipses and meteor showers, but also fly over different celestial objects at close range. Curriculum helps students understand planetary orbits and the three-dimensional structure of the universe intuitively. Some lessons have been shared with several planetariums. In the next step, more lessons will be developed, and more teaching plans will be designed according to the cognitive level of students at different ages to serve more students.

Talk link: https://youtu.be/ss49m--2DG8

In this contribution we share the basic situation and development experience of our “Dome Theatre Feature Astronomy Class” in the dome theatre of the China Science and Technology Museum.

The China Science and Technology Museum is the only national comprehensive science popularisation venue in China, with a 30-meter diameter dome theatre. In 2018, the theatre’s digital astronomical demonstration system was upgraded to use Digistar 6 software from Evans & Sutherland in the United States and 10 high-brightness laser engineering projectors from NEC in Japan. Using the powerful database and demonstration functions of the revamped system, we have developed 10 sets of interactive astronomy lessons, mainly for primary school students.

Through research and analysis, we determined that the main audience of the course is primary school students. For this group, we mainly consider two problems when designing the course: on the one hand, according to Piaget’s theory of cognitive development, due to the limitation of cognitive development level and spatial imagination, students have certain difficulties in understanding the knowledge content in the field of astronomy; on the other hand, for students who live in cities for a long time, there are fewer opportunities to directly view the starry sky, but with the improvement of living standards year by year, and in recent years, China has made great progress in the field of astronomy and space exploration, and the society generally has a greater demand for astronomy and aerospace science.

In terms of specific curriculum development, we mainly share three aspects. First, in the selection of course topics, from the traditional conventional astronomical content, such as constellations, the solar system, etc., to important celestial phenomena, astronomical frontier discoveries and hot events at key nodes of aerospace engineering. Second, in terms of content details, we refer to the “Science Curriculum Standards for Compulsory Education” (2022-year edition), focusing on the existing knowledge points of school education, based on the core concepts of 13 subjects, reorganising the curriculum content, and focusing on the teaching of interdisciplinary knowledge. Third, in teaching and expression, we pay attention to integrating core qualities such as scientific concepts, scientific thinking, inquiry practice, and attitude responsibility into the curriculum. Using the unique display characteristics of the dome, we can enhance students’ immersive experience, and display abstract astronomical content concretely to stimulate students’ curiosity and imagination.

Since 2018, we have conducted 30 courses with more than 5,000 participants. Courses have been shared with several provincial and municipal science and technology museums and planetariums. In the next step, we will develop and design courses according to the cognitive level of students of different ages to serve more students.

Development of a Non-Formal Education Curriculum in Astronomy for Middle School Students

Speaker: Avik Dasgupta, Vikram A. Sarabhai Community Science Centre, India

School Science Forum is a non-formal education course conducted at Vikram A. Sarabhai Community Science Centre for middle school children (standards 5–9) in Ahmedabad, India. As part of this, the astronomy lab has developed a curriculum so that we can gradually introduce students to the basic concepts of astronomy. The sessions are based on short lectures supported with hands-on learning, model making, observations, and discussions. The concepts included are moon phases, constellations, circumpolar constellations, day time astronomy & sundial and understanding & making a telescope for students from standards 5–9, respectively. Here we have discussed the development and various learnings from these sessions.

Talk link: https://youtu.be/Sx6s8WUWkCA

Vikram A. Sarabhai Community Science Centre (VASCSC), a pioneering institute with open labs was founded by eminent space scientist Dr. Vikram Sarabhai in 1966. School Science Forum is a non-formal education course conducted at VASCSC for middle school children (standards 5–9) in Ahmedabad, India. As part of this, the astronomy lab has developed a curriculum where the students are gradually introduced to the basic concepts of astronomy. The sessions are based on short briefings supported with hands-on learning, model making, observations and discussions. The details of each topic, related session, hands-on activity, and astronomical concepts covered standard-wise are tabulated below.

The curriculum was designed to be in parallel with the National Council of Educational Research and Training (NCERT) text books' concepts. In each session, we start from a daily life phenomenon and slowly bring in the related astronomical concepts, aided by hands-on activities and observations. Our content is standard appropriate, we gradually introduce a deeper level of content as students move to higher classes. We try to leave them with common answers and a lot more questions to ponder on. And finally inspire them to wonder about the universe and uniqueness of our Earth.

Standard 5

Topic(s)	Session	Activity	Astronomical Concepts Covered
Moon Phases	Moon Phases	Template based Moon Phases	New Moon and Full Moon; Period of rotation and revolution of Moon around Earth; Phases of Moon; Eclipses; Observations for next moon phase cycle

Standard 6

Topic(s)	Session	Activity	Astronomical Concepts Covered
Constellations	Constellations	Joining the stars to make a constellation chart	Identifying Constellations for a given time period; Drawing them and understanding the folklores behind them; Difference between constellation, asterisms and zodiacs; How zodiac leads to prediction and pseudo-science

Standard 7

Topic(s)	Session	Activity	Astronomical Concepts Covered
Circumpolar Constellation	Circumpolar Constellation	Template based Circumpolar Constellation clock	Review of different constellations; Seasonal and circumpolar movement of constellations; Difference of circumpolar movement in different hemispheres and latitudes using video; No pole star at southern celestial pole; Changing pole star due to precession; Accompanied by night sky observation, identification of constellations and night sky software.

Standard 8

Topic(s)	Session	Activity	Astronomical Concepts Covered
Solar astronomy	Sundial and sunspot observation	Template based horizontal Sundial	Introduction to Solar Astronomy; Sun daily, seasonal and yearly motions; Making horizontal sundial, understanding and observing; Sunspot Observation
	Sun projector	Making and observing Ball Mirror and understanding the rotation of Earth	Making a Ball Mirror and projecting the Sun's image to observe Earth's rotation; Understanding Sun as a star; Physics behind sun spots; Repeating Sunspot Observation and discussing the changes in spot positions

Standard 9

Topic(s)	Session	Activity	Astronomical Concepts Covered
Telescopes & beyond	Refractor Telescopes	Making Objective Box	Introduction to reflection and refraction; Working of refractor telescopes; Demonstration and handling refractor telescopes; Types of Mounts
	Reflector Telescopes	Making Eye-piece Box, assembling and calibrating	Different reflectors, i.e., Newtonian, Cassegrain, Coude; Demonstration and handling reflector telescopes; Resolution, Magnification and different filters
	Different windows of astronomy and path forward	Glimpse of data sets from different archives	Different windows of Electromagnetic Waves; Ground based and space-based observatories; Gravitational Wave Observatories; Future path ways to pursue astronomy; Staying connected with astronomy – citizen science projects

Developing and Practising Astronomy Curricula for Students Aged 5-6

Presenter: Stella Yang, China West Normal University, School of Physics and Astronomy, Nanjing, China

To explore how to develop a kindergarten astronomy curriculum suitable for Chinese children, we conducted a year-long school-based astronomy curriculum development and practice in a public kindergarten in Sichuan. Initially, we researched the national policy and the cognitive situation of astronomy in this early childhood class. We chose the eight solar system planets as the theme, incorporated the teaching concept of hands-on learning, and used handicrafts and games as the main activities and knowledge transfer as the support. After the development, we started a weekly 90-minute course practice for six months. It has been proved by practice that the course content "The Eight Planets" developed by us is very suitable as an enlightenment course for young children.

Poster link: https://astro4edu.org/siw/p83

To explore how to develop a kindergarten astronomy curriculum suitable for Chinese children, we conducted a year-long school-based astronomy curriculum development and practice in a public kindergarten in Sichuan. We chose to work with children aged 5-6.

Our team consisted mainly of astronomy majors but also included early childhood education and art students. We hired experts in early childhood astronomy education to review the content of the curriculum to ensure the correctness of the knowledge and to enhance the artistry, inspiration, and fun of the curriculum.

In the early stages of development, we researched the national policy and the cognitive situation of astronomy in this early childhood class. We determined the content and teaching format of the curriculum. We chose the eight solar system planets as the theme, incorporated the teaching concept of hands-on learning, and used handicrafts and games as the main activities and knowledge transfer as the support. After the development, we practised the curriculum for six months, once a week (90min). Based on the feedback from children, teachers, and parents, we iterated and modified all the classroom contents, hoping to form a series of astronomy courses that can be universally applied to any kindergarten.

The content we developed, "The Eight Planets" has proven to be a perfect introduction to astronomy for young children. Astronomy is an ideal subject for science initiation. It is not only related to life but also intersects with many disciplines and can open the door to science for children.

In the future, we will also devote ourselves to develop astronomy enlightenment content for young children, expanding from schools to families and science museums so that each child's small universe and the entire universe can be connected and a complete astronomy enlightenment education for young children can be realised.

Exploring the Universe in El Salvador for Public from 4-years Old

Presenter: Brisa Terezón, Micro Macro Observatory - Don Bosco University, El Salvador

We present the experience of developing workshops aimed at the public from 4-years old. The subjects of astronomy and microscopy were selected from the educational curriculum of El Salvador. For astronomy topics, we use teaching materials suggested by NASE. As for microscopy, the experience of Botanika in Bremen was taken as a basis. The workshop includes observations of the universe with microscopes and telescopes, to show in a practical way how small-scale universes make up large-scale universes.

Poster link: https://astro4edu.org/siw/p84

This workshop was developed by Micro Macro Observatory, located at Don Bosco University. The workshops' objective was exploring the universe on a small and large scale. The workshop includes observations of the universe with microscopes and telescopes, to show in a practical way how small-scale universes make up large-scale universes.

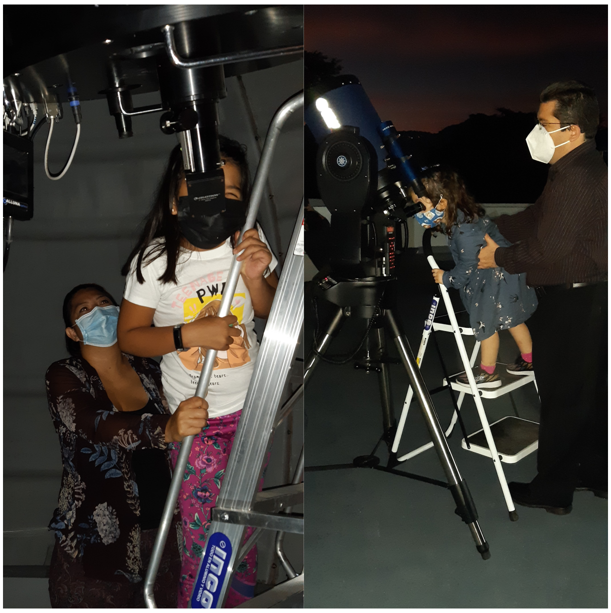
The subjects of astronomy and microscopy were selected from the educational curriculum of El Salvador, which include constellations, solar system, Earth, and Moon for the astronomy part. On the other hand, the main experiment with the microscope is the observation of onion cells (https://www.mined.gob.sv/guia-de-programas/). For astronomy topics, we use teaching materials suggested by NASE (Network for Astronomy School Education). As for microscopy, we used the experience of Botanika in Bremen, Germany to introduce children to the micro universe using a magnifying glass and microscope.

The main astronomy topics in our workshop were stars and constellations, solar system, solar and lunar eclipses, astronomy of position, star evolution, galaxies, and cosmology. About the telescopes, the activities were: main parts of a telescope, installing the telescope, types of telescopes, observing the sun, stars, moon, planets, and galaxies. The activities for microscopy were observing the flower garden, the microscopic world in the apple and exploring the Earth's rock.

The workshop was offered for public from 4-years old. We had 55 participants. The youngest was a four year old and the oldest was 74 years old. We used 10 hours to do hands-on activities and 10 hours for astronomical observations with naked eyes, microscope and telescope.

Micro Macro Observatory

Children using microscope



Children observing the Moon and planets using a telescope

Astronomy Education in Curriculum of Nepal

Presenter: Raj Kumar Dhakal, Science Teacher, Gandaki Boarding School, Pokhara, Nepal

The curriculum of Nepal is being prepared, updated and evaluated by the Curriculum Development Centre (CDC) under the Ministry of Education, Science and Technology in Nepal. Generally, the curriculum is being updated every 10 years and Nepal is in the phase of implementation of a new curriculum, which was prepared in 2022. As per the new curriculum astronomy is included under Science and technology from Grades 4 to 10 and Physics in Grades 11 and 12, and astronomy is not a stand alone subject, thus given less priority. One of the reasons for this could be the less interest of teachers and curriculum developers in astronomy education. With the new curriculum in place, there is a need for capacity building among the teacher and educators to facilitate the understanding of the knowledge along with the newer updates in the introduction of chapters and units in the astronomy in Nepali science books/curriculum.

Poster link: https://astro4edu.org/siw/p88

Although astronomy is a separate branch of science it has been included as a physics curriculum in Nepal. The curriculum of Nepal is being prepared, updated and evaluated by the Curriculum Development Centre (CDC) under the Ministry of Education, Science and Technology in Nepal. Generally, the curriculum is being updated every 10 years. According to the policy, Nepal is currently in the phase of implementing the new curriculum, that was prepared in 2020. The new curriculum was implemented for Grades 1, 6 and 11 in the year 2020, for Grades 2, 3, 6, and 12 in the year 2021, for Grades 4, 7 and 9 in the year 2022 and for Grades 5, 8 and 10 will be implemented in the year 2022. As per the new curriculum of Nepal prepared by CDC, astronomy is included under the curriculum of Science and technology from Grades 4 to 10 and Physics in Grades 11 and 12.

Looking at the scenario, our curriculum gives less priority to astronomy education. One of the reasons for this could be the little interest from teachers, educators and curriculum developers in astronomy education. In spite of this, astronomy education is being included in each level now as a major unit.

The inclusion of astronomy in curriculum is divided into following points:

1. Basic level (For classes 4 and 5)
   Earth and Space: The topics are related to Structure of the earth, Various spheres of the earth, Weather and climate, Weather forecasting, the sun, the moon and the earth including revolution and rotation of the earth and moon, Phases of the moon, etc.

2. Basic level (For classes 6 to 8)
   Earth and Space: Soil, Rocks and Minerals, Soil profile, Layers of the earth, Season change on the earth, the sun and the Solar system, Phases of the moon and Lunar Calendar, Eclipse and causes, Universe, Asteroids, Comets, Constellations, Galaxies, Meteors and Meteorites, Evolution of the living organisms on the earth.

3. Secondary level (For classes 9 and 10)
   Astronomical units, Nebula and black hole, Life cycle of star, National/ International agencies working in astronomy, Importance in gravitational force, Origin of the Universe according to Big bang theory, Conclusion of Hubble's law, The future of universe on the basis of gravitational force.

Astronomy in Brazilian Basic Education: a Look at BNCC of Elementary School

Presenter: Thais Alexandre, Universidade de São Paulo, Brazil

Collaborators: Taynara Nassar and Cristina Leite (Universidade de São Paulo, Brazil)

Astronomy is present in the Common National Curriculum Base in Brazil. The analysis of this document enabled us to build an overview of the themes related to astronomy in elementary school. It was possible to perceive that there is an indication for proposals of sky's observation, with identification of heavenly bodies and comprehension of the movements of the Earth, Sun and Moon, as a way of understanding periodic phenomena on the first cycle of elementary school. In the second cycle, the focus is the construction of relations between sky's observations and scientific models, enabling the construction of arguments, interpretations and justifications based on scientific evidence for these phenomena, in addition to deeper studies about the dynamics of the heavenly bodies of the Universe.

Poster link: https://astro4edu.org/siw/p85

Astronomy is one of the oldest sciences, being present in several situations everyday, and reference for aspects such as time counting, agriculture, and others (Caniato, 2011). The subject has been present in the brazilian curriculum since colonial time (Leite et al., 2014) and remained nonlinear in the following century, even in context of change and curricular reforms (Hosoume et al., 2010).

The current Brazilian curriculum document, the Common National Curriculum Base (BNCC, in portuguese), presents science thematics in competency format, abilities and knowledge objects such as learning rights by school levels and/or years. The astronomy thematics are more explored in the curriculum component science, in the thematic unit Earth and Universe (Brasil, 2018). Astronomy is present in all basic schools, and its themes are expressed by abilities and proposals that involve the understanding of Earth, Sun, Moon and others heavenly bodies, sky observations, and cultural astronomy, for example. This summary presents an analysis of these actions expressed by the verbs in astronomy's abilities and verifies how they develop throughout elementary school.

Methodology: The analysis was made from a reading of BNCC, specifically of the science part from elementary school, which identified the abilities that have a direct relationship with astronomy knowledge objects and the associated verbs. The verbs were analysed qualitatively, and are associated with the framework of scientific research processes and practices listed in the BNCC, which divides them into stages: problem definition; survey; analysis and representation; communication and intervention (Brasil, 2018, p. 323).

Analysis and Results: The analysis allowed us to identify that the astronomy's abilities propose action related with practice, process and scientific investigations procedures, as proposed in the document. The application of these actions is convergent with the proposal too, to promote learning and more distributed learning throughout elementary school.

It is possible to identify the presence of contents marked by experimental processes and sky's observations on the first cycle, related to the defined problem, interpretation and construction of argumentation. On the second cycle, the verbs indicated proposals with greater emphasis on deepening, expanding the world view through the articulation between different points of view, and can also be related to stages of analysis, representation and communication. It is noted that verbs related to the communication and intervention stages are less present in the skills analysed. Understanding the dynamic of teaching and learning that is proposed is fundamental to think and rethink the practice of teaching astronomy in the classroom, the organisation of didactic material based in the curriculum distribution proposal and for the initial and continuing training of science teachers for basic school.

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“Colonization of Mars – Challenges and Solutions” – a Game-Based Activity

Presenter: Eleana Balla, NOESIS - Thessaloniki Science Center and Technology Museum, Greece

Educating people on astronomy and space science can act as a "gateway" that opens a world of possibilities by nurturing inquisitiveness and the pursuit of knowledge using the scientific method. Moreover, as astronomical research is technology driven, astronomy and space education provide excellent opportunities to enhance different aspects of STEM education. NOESIS being inspired by the human’s plan to colonise Mars developed the game based activity "Colonisation of Mars-challenges and solutions" for secondary students. Using tablets and an android app the students are dealing with challenges and situations faced by scientists, experts and astronauts in the colonisation project of Mars.

Poster link: https://astro4edu.org/siw/p86

Science, Technology, Engineering and Mathematics (STEM) play an important role in contemporary society. They shape an area that transformed our lives and is continuing to evolve and determine our world, building the sustainable society of the future. In such a society, computational, social and cultural skill as well as creativity, critical thinking and problem solving are essential for the citizens. While schools and universities are mainly responsible for educating the youth, the non-formal sector plays a critical role integrating science learning and developing 21st century skills.

Educating people on astronomy and space science can act as a “gateway” that opens a world of possibilities by nurturing inquisitiveness and the pursuit of knowledge. Moreover, as astronomical research is technology driven, astronomy and space education provide excellent opportunities to enhance different aspects of STEM education.

In most European countries, there is not a stand-alone educational curriculum of astronomy in the secondary level. On the other hand, in non-formal organisations, such as planetariums and science centers, astronomy and space science are strongly represented, remaining among the most popular topics. In the context of the "Future Space" erasmus plus project, teachers and science centers worked together to develop an astronomy and Space Program for secondary school students. The program contains lesson scenarios that can be performed by teachers in school classes and activities that can be implemented during a school visit to a science center.

NOESIS science center, being inspired by the human’s plan to colonise Mars developed the game-based activity “Colonisation of Mars - challenges and solutions”. Using tablets and through an android app, which has been designed for this activity, the students are dealing with challenges and situations faced by scientists, experts and astronauts in the colonisation project of Mars.

The 90-minute activity takes place in a properly equipped room, facilitated by 1-2 facilitators. Starting with an introduction, a short-guided discussion reveals students' ideas about human efforts to visit and colonise Mars. During the experimentation phase, the students in groups are moving around working stations to perform five different tasks. Each task, which is fully described in a dedicated board, transfers students to a specific place and time, assigns them to a specific role and sets a unique goal. Diverse tools and means (boards, cards, 3D objects, lab equipment, tablets) are used to practice different students' skills. Finally, at the reflection phase, the students discuss in plenary their work and outcomes and scientific information and up to date data from current research are provided.

The elements of Inquiry based learning (essential questions, student engagement, cooperative interaction, performance evaluation, variety of responses) and the elements of Gamification (the tasks determine the goals, the environment represents real-world situations and the students are digitally engaged) are present. Collaborative Learning is also met, as students while working in groups, take on specific roles, try to accomplish certain goals and share ideas, understanding and communication.

The activity is available for school classes visiting NOESIS. During the school year 2021-2022, thirty-five classes and 1200 students participated. An evaluation of the activity by using questionnaires is in progress.

Resources:

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  https://www.tandfonline.com/doi/full/10.1080/03057260903562284

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The Strengths and Weaknesses of Astronomy in the Curricula and Some Suggestions that can be Implemented to Advance Astronomy

Presenter: Mostafa Mohamed Mostafa Mohamed, Science teacher at El Salam Preparatory School for Boys in Cairo, Egypt

As a science teacher in Egypt, I would like to share my experiences in science education and astronomy curricula for school students aged 12-15. I will display some points of strengths and weaknesses in astronomy curricula and the methods of astronomy education. I will also give some suggestions, which may help improve the situation.

Poster link: https://astro4edu.org/siw/p87

Strengths:

- In the first year of middle school (second term) students learn about celestial bodies and then learn about our planet Earth.
- In the second year of middle school (first term) students learn about the different layers of the atmosphere and the phenomena associated with each layer.
- In the third year of middle school (first term) students are introduced to the theory of creation of the universe and the theories Of the formation of the solar system.
- Students learn about the existence of life on planet Earth.
- Students identify climate problems and their direct impact on life.
- Students learn about the solar system, planet Earth, and the occurrence of some astronomical phenomena.

Weaknesses:

- The weight of astronomy curricula on the student during the educational process.
- Unavailability of teaching aids, such as planetariums, scientific museums, and augmented reality technologies (simulation).

- Unavailability of real cultural awareness in society of the importance of many sciences.
- Society's feeling that there is no direct financial return from these sciences.
- There are some misconceptions held by many of those involved in the educational process.

Suggestions:

- Providing visitor access at scientific museums for universities and institutes, which will make the educational process more interesting for students and have many benefits as well, such as informing the student of the stages of development of science and technologies.
- Increasing cooperation between scientific research institution and educational institutions to assist those in charge of education to acquire correct concepts that develop from time to time with the development of research.
- A systematic distribution of a curriculum for astronomy.
- A good marketing of astronomy (as is done for some other science branches like medicine and engineering) is important because there are many technologies that society enjoys without realising the role of fundamental sciences like astronomy and the scientists that work on them.
- Providing visual aids such as virtual reality techniques and videos, planetariums, which are provided by many developed countries to assist the educational process.
- "What will we benefit from studying astronomy?" - a question asked to every science teacher. This question can be answered by mentioning the achievements that astronomy contributes to, which facilitate many of our daily operations, such as using the GPS and various communication and broadcast networks.

I think that if the ideas described above are implemented, we will be able to inspire students to learn eagerly, provide them with good educational materials, train the teachers to teach effectively, and build a cultural awareness in the parents and the community in general; these will help the country become more prosperous.

Discussion summary

Developing any curriculum requires one to be highly passionate and motivated about one's* field of study. It also requires students' interest in the subject. In the session discussions, the motivation for the teachers to develop these was based on their love for science and more so, sharing this science with their inquisitive students. Much of the developed curriculum has been improved through the feedback from the students, as our invited speaker has mentioned, 'the motivation was the feedback from students, which made us realise that they are interested regardless of age'. This was not unique to the invited speaker as the sequencing of the content and activities given to students was also based on the feedback from both the teachers and students. This shows that, unlike in the traditional sense, a curriculum can be both a top-down and bottom-up approach, where students' interests can drive the content and the teachers or ministries drive the learning goals.

The contributed talks also shed light on different aspects of developing an astronomy curriculum, including the difficulties of it thereof. For example in many countries, astronomy is not necessarily its own subject, it is rather included as part of the other sciences. Introducing it as a curriculum makes its implementation difficult at times, however, integrating aspects of it in subjects such as Physics, Mathematics, Chemistry, Geography, and technology has been helpful. More so, astronomy has transferable skills that can be used in the learning and teaching of other subjects.

When it comes to technology, we see its potential in astronomy, from telescopes to planetariums, especially in recent years with the introduction of digital planetariums. One of the speakers developed the curriculum in the science museum where they have a three-dimensional theatre, they try to use a three-dimensional model to give the students an immersive, 3D impression in which they cannot demonstrate their ideas. This helps students with understanding difficult astronomical concepts, and the immense dimension of our universe. Overall, developing a curriculum is not only limited to the classroom; planetariums and science museums alike are also a way of developing, but it is important that the curriculum still aligns with the national standards of the country, which are sent out by the Education Ministry.

The implementation of the curriculum and its continuity can only be achieved when the curriculum does not belong to a person but rather is shared with other teachers, developers, and ministries. Once the ministries approve the curriculum, it is implemented by the teachers. However, it is also important to train pre-service teachers on how to teach the new curriculum, so that when the old teachers retire, there are still new teachers that are going to continue with the vision of making their students scientifically literate. It is also important for teachers to be aware of the students' diversity, for example, learning how to cater to students with special needs in their science classroom.

The speakers also discussed the key things to consider when developing and organising the curriculum and its excursion (teaching it). From the training teachers' perspective, the emphasis is on teaching 21st-century skills, which the teachers can use in their classrooms, to keep learners engaged and interested. Using a lot of theory-based methodologies, such as constructivistic approaches, and problem-based learning techniques that are research-based.

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