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).

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

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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

Astronomy in Schools: How Do You Get Your Administration and Your Ministry to Listen?

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

One of the goals of the Office of Astronomy for Education (OAE) is to professionalise astronomy education for formal education in primary and secondary schools. The main challenge that is faced in many parts of the world, is that astronomy is not included in the schools' curriculum. Introducing astronomy in the curriculum means, planning and designing content, material, and activities for that section. In this session, we will hear from astronomy professors, lecturers, and teachers who have had the experience of advocating for astronomy education in schools, with the ministry of education.

In this session, the speakers have had the opportunity to advocate for the inclusion of astronomy within their school curricula. An interesting aspect of this lies in the fact that the outreach initiatives alone are not sufficient to make astronomy well-known to the general public. As such, the more practical way of improving astronomy literacy, is through entering astronomy in formal school. Another interesting aspect, brought through by the invited speaker is that when the ministries and governments are already open their ears to listen, collaboration can be fostered to ensure the inclusion of astronomy within the curriculum.

The key aspects of advocacy include initiating, communicating, educating, and collaborating. Initiating means taking the first step, and in the context of astronomy, taking the first step in acknowledging the need for reform, access, and inclusion of astronomy in schools. Communicating, follows the initiation step, as it seeks to allow different stakeholders to engage with one another to identify key issues, problems, and solutions. Educating is closely linked to communication, as it seeks to improve the knowledge of the people directly involved i.e., the teachers (internal - through teacher training pilots), and improve the knowledge of the administrations and ministries (external). And finally, find ways to collaborate and bring the vision to fruition. These aspects we have clearly seen in the talks given in this session.

Talk contributions

Embedding Modern Astrophysics Within the High School Physics Curriculum in Scotland

Speaker: Martin Hendry, School of Physics and Astronomy, University of Glasgow, United Kingdom

For more than a decade the national high school physics qualifications in Scotland have included key units on astrophysics, quantum and particle physics, cosmology, and relativity. The focus of these topics has been not so much what scientists have learned, but how they have done so – thus giving students (and teachers!) greater insight into general principles of scientific research, including critical thinking and problem-solving skills. The focus on open-ended enquiry also aligned with the "Curriculum for Excellence": the comprehensive reform of Scottish education carried out across all subject areas. Here I reflect on the experience of re-vamping the content and principles of high school physics education, in the context of the wider educational reform introduced in Scottish schools.

Talk link: https://youtu.be/DolQ7LoaCn8

In 2010 a new approach to primary and secondary education was introduced in schools throughout Scotland. Known as the "Curriculum for Excellence" (CfE), this initiative sought to achieve a transformation in Scottish education by providing a coherent, more flexible and enriched curriculum for children aged 3 to 18. The CfE aims to help every learner develop knowledge, skills and attributes for learning, life and work, and its implementation has brought about some significant changes to the physics syllabus covered in the "Senior phase" of high school.

More than a decade later these changes generally appear to have bedded in well, and have introduced tens of thousands of high school students (and many teachers!) to some of the latest developments and ideas in astrophysics, cosmology, particle physics, relativity, and quantum physics. The new material has also been presented within the context of a more open-ended approach to teaching CfE science that builds critical thinking, data analysis and other transferable skills; in this sense, the inclusion of more (astro)physics content has been important as much for what it conveys to students about *how* we have come to understand the cosmos, as it is about *what* we have learned.

Key to the successful implementation of these exciting developments has been the teacher support and infrastructure created and maintained by numerous stakeholders that include Education Scotland and the Scottish Qualifications Authority, the Institute of Physics in Scotland, the Scottish Schools Education Research Centre (SSERC), Scottish University departments of Physics and Astronomy and the Scottish University Physics Alliance.

The CfE Higher and Advanced Higher Physics Courses

While the CfE has sought to foster positive changes in the teaching of science at all levels, in this short report I will focus solely on the "Higher Physics" and "Advanced Higher Physics" courses taught during the Senior Phase of High School (usually students' fifth and sixth year of study).

The Higher Physics course comprises four teaching units, three of which have been significantly updated:

- In "Our Dynamic Universe" students are introduced to the basic concepts of special relativity (including time dilation and length contraction, deriving the relevant formulae from first principles), the Hubble expansion and evidence for the hot Big Bang (including black-body radiation and the cosmic microwave background radiation).

- In "Particles and Waves" students learn about qualitative features of the Standard Model of particle physics, emphasising not just how far this theory has come but also where the remaining gaps in our understanding lie. Particles and Waves also introduces the key ideas of wave-particle duality, focusing on the photoelectric effect, the double slit experiment and its implications for a quantum description of reality.

- In the new "Researching Physics" unit students undertake a short piece of research on a topical subject of their choice. Popular subjects that schools have chosen include, for example, exoplanets – where students learn about exoplanet detection methods and e.g., analyse transit light curves, to test simple hypotheses.

The **Advanced Higher Physics** course also comprises four teaching units, with again three of them re-vamped to contain enhanced astrophysics / relativity / quantum physics content:

- In the new "Rotational Motion and Astrophysics" unit, students build upon special relativity covered in the Higher Physics course and are introduced to the key ideas of general relativity via the Equivalence Principle, to a qualitative discussion of the geometry of curved spacetime and to simple calculations related the Schwarzschild radius and the event horizon. This unit also includes a basic description of the lifecycles of stars and the Hertzsprung-Russell diagram.

- In the re-vamped "Quanta and Waves" unit, more basic quantum physics is introduced - including the Bohr atom and the concept of the de Broglie wavelength – that significantly extends the material covered in the Higher course.

- Finally, in the "Electricity and Magnetism" unit, students learn how the speed of light connects to the permittivity and permeability of the vacuum – together with the broader significance of James Clerk Maxwell's unification of the electric and magnetic fields.

Lessons learned from the Scottish experience

The inclusion of new astrophysics material has been generally popular with both students and teachers, but it has taken many teachers far from their comfort zone. Contributing to this is the fact that there is not a rigidly defined syllabus for the Higher and Advanced Higher courses but instead a series of "Experiences and Outcomes" outlining the content that students would be expected to understand. However, this flexibility in the detail of how the courses are taught in each school has resulted in an impressive degree of collegiality across schools and local education authorities. The Institute of Physics in Scotland has been a prime mover in collating and promoting these shared, teacher-led resources, and in moderating the Scottish physics teachers' online discussion forum, SPUTNIK, which many teachers use to discuss the astrophysics content and how best to teach it. These discussions have been particularly valuable around how to prepare students for the open-ended questions that are now firmly part of the national qualifications exam papers; the goal of these questions, to encourage students to "think more like a physicist" rather than relying on rote learning, is a worthy one, but is challenging nonetheless. IOP Scotland and SSERC also provide hugely valuable teacher CPD opportunities, both in-person and online, and have helped to build confidence in higher-level experimental skills such as dealing with errors and measurement uncertainties.

Overall, then, the success of the Scottish experience should give confidence to other countries or regions seeking to convince their education authorities to include more astrophysics content. Key factors that can contribute to making a strong case would appear to include:

- the political and economic demands for more STEM engagement, to address possibly significant future employment gaps and shortfalls;

- exploiting the proven popularity of astronomy amongst students, and the way in which it can build broader STEM skills that will be needed to plug these gaps and shortfalls;

- the importance of providing effective teacher support, through partnerships between universities, professional bodies and other stakeholders.

Promoting Astronomy Education in Schools: 20 years' Practice in China

Speaker: Jin Zhu, Beijing Planetarium, China

Shortly after I came to Beijing Planetarium as its curator in 2002 from National Astronomical Observatories, I realised that the 1 million visits every year to the Planetarium is far beyond sufficient comparing to the 20+ million population even in the city itself. It is obvious that making astronomy one of the courses within normal school curriculum like language and math would be a fundamental solution to have everyone enjoy the wonder and beauty of astronomy and universe. With support from the Popularisation Working Committee of the Chinese Astronomical Society and other organisations, we made different efforts with national or local projects and activities, as well as contacting administrations at different levels. Some results and lessons from the 20 years' practice are summarised.

Talk link: `https://youtu.be/1nlN3_bD8U8`

Twenty years ago, in Sept. 2002, I came to the Beijing Planetarium (BJP) from the National Astronomical Observatories, Chinese Academy of Science, and became the new curator of BJP. The planetarium was built in 1957 and was making the upgrade with a new building at that time. In Dec. 2004, the new building was completed and the planetarium was reopened to public. Visitors to BJP grew to more than 1 million visits (which was a sum for visitors to exhibit area only and to each of the 4 different theatres) during the next year, which was an obvious increase compared with previous years. However, I realised that such a number was still very limited compared to the more than 20 million population of the city. It will take more that 20 years to have every person in the city visit the planetarium once in their life time, considering the newly born children and large percentage of visitors from the whole country.

I realised that only a large and modern planetarium was not sufficient to make astronomy well-known to the public. The more fundamental way to solve the problem should be to have astronomy included in the formal school educational system as a course, similar to mathematics and languages. As the director of the Popularisation Working Committee of the Chinese Astronomy Society (PWC/CAS), which is usually the same person as the BJP curator, I made the statement to promote astronomy education in elementary and middle schools, and hoped that astronomy could be a part of the normal school curriculum before my retirement.

Some steps towards the goal were performed at the BJP during 2002/2003, including setting-up the Chinese National Astronomy Olympiad, adding more content on astronomy education in our Amateur Astronomer magazine, and starting an astronomy class (with teachers from the BJP) for the first year students of the Huangsongyu middle school located in a suburban area with quite good night-sky observing conditions.

Before 2000, all elementary schools and middle schools in China had the same curriculum with same teaching program and textbook. In June 1999 and June 2001, reformation of the national education system had started and the management of 3 levels of curriculum with national, regional, and school-based curriculum was implemented, which made it possible for astronomy to be selected as a school-based curriculum.

Starting from 2007, some elementary schools and middle schools in Beijing and Tianjin started their school-based astronomy curriculum. Every student had an astronomy course at least in one grade with 2 class hours per week, some even had astronomy courses in three or five grades. BJP and PWC/CAS started nation-wide teacher training programs together with other organisations like the Tianjin Science and Technology museum and the Astronomy department of the Beijing Normal University.

In Dec. 2011, I visited Nepal as part of the IAU Commission 46 (Astronomy Education and Development) Program Group for the World-wide Development of Astronomy (PGWWDA). I gave a lecture at the university there, and visited the Minister of Nepal Ministry of Education, Science and Technology to advocate for the importance of astronomy for education and social development. Based on my understanding about the importance of astronomy on education, I wrote a letter to the Minister of Chinese Ministry of Education suggesting to introduce astronomy in normal school curriculum just like mathematics, physics, chemistry, and other natural sciences.

In June 2014, BJP hosted the 22nd International Planetarium Society (IPS) Conference under the theme of "Educating for the Future", focusing on the significant role of planetariums in future astronomy education. In Sept. 2014, Delingha Planetarium in the Haixi State of Qinghai Province was opened to the public. Delingha is the place where the 13.7-m Millimetre-wave Radio Telescope of the Purple Mountain Observatory is located. I visited Delingha (the capital city of Haixi State) with some BJP colleagues to talk to the leaders from the City and State Bureaus of Education on including astronomy courses for all Grade 7 students in the city distributed in 16 classes within 5 middle schools, with 16 90-minutes class hours each semester for every student. We helped with educational programs and the students were brought to the Planetarium for their astronomy classes.

The most successful astronomy education program in China should be the one in the Pingtang county of the Qiannan Buyi and Miao Autonomous Prefecture, Guizhou Province, where the five-hundred-meter Aperture Spherical Radio Telescope (FAST) locates. FAST started its commissioning on Sept. 2016. During the visit to BJP by the vice-governor of Guizhou Province in May 2017, I proposed that astronomy education in school curriculum is very important for every inhabitant considering the huge number of visitors at FAST. It was decided that astronomy will be a school-based curriculum for 30+ elementary and middle schools in the county from the new semester starting in Sept. 2017, and I came to Pingtang with experts from BJP and Tianjin Science and Technology Museum for teacher training courses in August. By Sept. 2020, all 82 elementary and middle schools in Pingtang County had astronomy courses in the curriculum, with a total of 36086 students and 26893 families involved.

The establishment of IAU OAE Center China at the BJP is now starting a new era of astronomy education in China.

From 20 years' practice of promoting astronomy education in schools, some experiences and lessons could be learned. The understanding from school masters and higher level authorities is important, and it is always necessary for astronomy outreach and communication with all efforts. Teacher training plays an important role in astronomy education, and local astronomy teachers in schools are more important than outside experts for a successful and sustainable program. Astronomy education in schools around some astronomical facilities might be easier to start, as well as at locations of planetariums or science museums/centers. Organisations like PWC/CAS or BJP could play an important role in this field. A systematic evaluation for the current programs may be needed for further investigation and improvement.

The New Astronomy Curriculum Pilot Program in Turkey

Speaker: Aysegul F. Teker Yelkenci, Department of Physics, Istanbul Kultur University, Turkey

A new astronomy curriculum study for secondary schools by the Ministry of Education in cooperation with TÜBİTAK (the Scientific and Technological Research Council of Turkey) is in preliminary progress since 2021. Three extended astronomy and astrophysics courses have been proposed for secondary education in science high schools in Turkey. One these courses has been approved for the pilot program to be applied in TÜBİTAK Science high school. Detailed teaching program of the "Astronomy and Universe" mandatory course is designed in cooperation with astronomers, physics teachers, course development and design experts, and evaluation and assessment experts. A group of astronomers and physics teachers are now working on the textbooks for the new pilot program starting in 2023.

Talk link: https://youtu.be/42IiVzBP8YU

In this contribution, curriculum development studies to achieve effective science teaching at the secondary level are examined. The analysis results revealed that 60% of the teachers did not find the current classical science curriculum to meet the needs of science teaching [1, 2]. The recent studies show that the information, media, and technology skill areas were the most involved in the 2018 curriculum, which is the latest version [3]. A new curriculum study for secondary schools is initiated by the Ministry of Education in cooperation with TÜBİTAK (the Scientific and Technological Research Council of Turkey) in November 2021.

TÜBİTAK science high school was chosen for the trial studies of the modern science teaching programs developed. TÜBİTAK science high school only accepts students from first 1% of the high school entrance exam and was established by the Scientific and Technological Research Council of Turkey – TÜBİTAK itself in 2021. The new pilot program aims to improve the science high school curricula by developing the mandatory and selective course programs. Evaluation studies were carried out for many new courses such as “Astronomy and the Universe”, “Innovation Oriented Project Design”, “Financial Mathematics”, “Human-Machine Interaction”, “Epidemiology”, “Polymer Chemistry”, “Future Energy Systems”, “Data Analysis”, “Artificial Intelligence Applications”, and “Ecology”.

The science high school curriculum development workshop was held in Antalya between 8-12 March 2022, within the scope of the cooperation between the Ministry of National Education General Directorate of Secondary Education and TÜBİTAK. With the participation of the head of Curriculum and Textbooks department, head of TÜBİTAK, expert academics and teachers in the workshop, development studies were carried out to ensure that the subject-acquisition-skill relationship in the related course contents of science high school is reflected effectively in the learning-teaching process.

In secondary education in Turkey, astronomy is covered in physics courses but it is also offered as a selective course in grades 9 and 10 [4]. Three new extended astronomy and astrophysics courses have been proposed for secondary education in science high schools in Turkey in 2021. One of these courses have been approved for the pilot program to be applied in TÜBİTAK science high school. Detailed teaching program of the “Astronomy and the Universe” mandatory course has been designed in cooperation with astronomers, physics teachers, course development and design experts, evaluation and assessment specialists.

A group of astronomers and physics teachers are presently working on the textbooks for the new pilot program to start in 2023.

References:

1. Demirbaş, M. and Yağbasan M., (2005), “Analysis Of Science Curriculums Applied At High Schools In Turkey: Modern Science Curriculum Applications”, Gazi; University Journal of Kirsehir Educational Faculy, Volume: 6, No: 2, 33-51

2. Aslan Z., (2006), “Astronominin Fen Bilimleri Eğitimindeki Yeri Sempozyumu İstatistikleri”, `http://astrobilgi.org/astronominin-fen-bilimleri-egitimindeki-yeri-sempozyumu/`

3. Doğru M., Çelik M. and Yildirim Kirbaci G., (2021), “Science Curriculum in Turkey from 21ST Century Skills’ Perspective”, Socialinis ugdymas / Social education, Vol. 55, No. 1, pp. 42–58, 202.

4. Doğru, M. , Satar, C. & Çelik, M. (2019). “Astronomi Eğitiminde Yapılan Çalışmaların Analizi”, Euroasian Journal of Social and Economic Research, 6 (7), 235-251.

Astronomy Education in the Curriculum and Schools of Iran

Speaker: Maryam Papari, Ministry of education, Iran

Astronomy education is one of the favourite activities of Iranian students and teachers and in recent years we have seen a growth in the number of schools focusing on astronomy education. Mehr Observatory, as the center of astronomy education in the Ministry of Education of Iran, has prepared plans and programs in order to develop astronomical activities in schools and has implemented it in collaboration with the education departments. Astronomy education in Iran increases the academic level of students and also leads to the realisation of goals such as sustainable development, environmental protection, and the advancement of women and girls. In this contribution, we examine the official education and the role of the department of education and its support for including astronomy in Iranian school curriculum.

Talk link: https://youtu.be/YsTK6QFxyok

Mehr Observatory is an astronomy training centre for teachers and students, belonging to the Ministry of Education, located in Bushehr province in the south of Iran. In the education system of Iran, in every city, in addition to the school, there is a student research centre, which are mostly laboratories, and the only student research centre that is an observatory in Iran is the Mehr Research Centre.

First, I would like to mention the role of astronomy in Iran's curriculum and textbooks. Despite the interest of many students in astronomy, no specialised astronomy course is taught in Iranian schools, and astronomy lessons are only introduced in the fourth, sixth, eighth and ninth grades. This is useful, but these lessons alone cannot satisfy the curiosity and answer students' questions.

According to the interest of our students and after assessing the needs and consulting with Iranian research institutes and educational institutions, with teachers who taught topics such as social sciences, psychology, art, history, literature, etc. and at the same time were also active in the field of astronomy, we held a meeting and searched for ways to increase the capacities of the curriculum in line with the development of astronomy in the country's schools.

Then, considering UNESCO's 2030 document and plan's strategy, we came to the conclusion that each of these disciplines can have a strong potential to attract students to astronomy and familiarise them with this science. So, in this way, we formulated plans for implementation to deliver to the General Administration, which after review, we can implement in schools, which is discussed in detail below.

Since the plans and activities that were prepared were not in the curriculum, we decided to organise meetings with the heads and vice-presidents of the education departments and then present and justify the plans. In the meetings, we explained the programs and since our focus was on teachers and students, fortunately, it was approved by the authorities and they decided to support the implementation of the programs.

To prove the effectiveness of the plans, we implemented them several times, such as explorers' festival, in-service courses for teachers, camping, etc.; then we presented successful examples to the education authorities, which were effective in accepting the plan.

During festivals, workshops and events, we used to invite the Education Department and authorities to visit the program. Every time the officials saw the students' interest in the sky and astronomy in the festivals and programs they decided to develop the activities and help the student's progress in astronomy.

We hope that all students who are interested in astronomy will have the opportunity to study the sky and we will not hesitate to make any effort.

Astronomy as a Tool to Improve High School Scientific Education in Peru

Speaker: Gabriela Calistro Rivera, European Space Observatory, Germany

Collaborators: Diego Alvarado Urrunaga (UNI), Daniella Bardalez Gagliuffi (Armherst University), Pamela Flores (LMU), Lisseth Gonzales Quevedo (UNMSM), Daniel Kleffman, Erick Meza (Comisión Nacional de Investigación y Desarrollo Aeroespacial del Perú - CONIDA), Vanessa Navarrete (UNMSM), ADita Quispe Quispe (IGP), José Ricra (AFARI), Bruno Rodríguez Marquina (Bonn University), Erika Torre Ramirez (UNI), Anthony Esteban Figueroa Quiñones (UNI), Sonia Diana Quispe Mamani (UNSA), and Lilian Fiorella Mucha Huaire (UC).

In this contribution, I presented the CosmoAmautas project. 'Amauta' means 'teacher' or 'knowledgeable person' in Quechua, the most widely spoken indigenous language in Peru. CosmoAmautas was developed with the vision to contribute to a stronger and more equitable scientific education in Peru, focusing on the most vulnerable socio-economic sectors that are commonly distributed in rural regions away from the capital city of Lima. CosmoAmautas is an initiative of early-career Peruvian astronomers working abroad together with astronomers with affiliations spanning most local institutions involved in astronomy in Peru.

Talk link: https://youtu.be/1YmxhS51m2Y

Figure 1: Examples of the inquiry-based learning activities done with the teachers as part of the virtual training.

Two aspects were essential in defining the CosmoAmautas educational strategy: multiplicity and self-sustainability. Therefore the core of the program are the teacher training programs, which have taken place two years in a row now, in a virtual format in six all-day sessions in 2021 and 2022. Combining the two sessions, 120 teachers from rural high schools were selected to participate in the training. We paid particular attention to gender balance and cultural and ethnic diversity in the selection of the participants, with 35% of the teachers identifying indigenous languages as their mother tongue. The teachers were selected to be representatives of 13 regions out of the 24 Peruvian regions. Through their teachers, we estimate that this initiative has reached more than 7000 high school students.

The teacher training: The six sessions were divided into different topics across all cosmic scales, including: the Earth–Sun–Moon system, Solar System, stars, exoplanets, galaxies and cosmology. Each session (six hours) was divided into two main parts. The first half consisted of hands-on inquiry-based learning activities in which the teachers explored the topic in small groups with the support of an instructor, approaching one specific question, hypothesising the answer, testing these hypotheses through experimentation, and finally presenting their conclusions. These activities included the measurement of the Earth's diameter, the comparison of Solar System scales using rice grains, the exploration of stellar parameters using a home-made spectrograph, the simulated search for exoplanets from real data, the measurement of our Galaxy's rotation using GAIA data, and the reconstruction of cosmic history using the Hubble Ultra-Deep Field image. The second half of the day consisted of interactive lectures on astrophysics, science education and pedagogy, gender balance, local ancestral astronomy, and climate change.

The virtual education system imposed by the COVID19 pandemic also revealed new necessities from the teachers in terms of virtual teaching strategies, which prompted us to redesign our hands-on inquiry learning methodology for achieving the same impact in a virtual context. This change motivated the introduction of smaller groups of teachers using breakout rooms, and we developed inexpensive and innovative digital educational tools, such as astronomy-focused educational video games tailored to complement our activities (available in Spanish on our

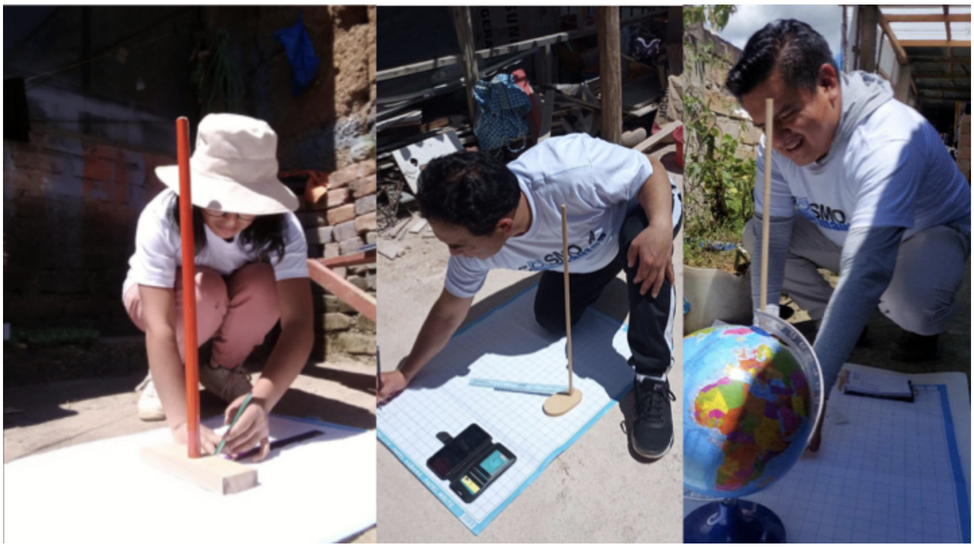

Figure 2: Teachers from different regions measuring the diameter of the Earth using the shadow of a gnome.

webpage: www.cosmoamautas.org

In order to ensure the equitable participation and engagement of teachers, we designed and shipped educational boxes across the country with all required materials to be used for the inquiry-learning activities. The materials included a text and activity book, which our team wrote to respond to a lack of accessible yet up-to-date astronomy content in Spanish at an advanced high school level. The CosmoAmautas book (160 pages, https://arxiv.org/abs/2109.11945) is a unique open-access resource for teachers who want to integrate astrophysics in their classes, combining the theoretical framework with our hands-on inquiry-learning activities.

Astroclubs: The most direct evidence of the impact of the program is the implementation of after-school astronomy clubs, 'AstroClubs', which began to take shape out of the teachers' own drive, even before the workshop sessions had culminated. From the two years of the program, more than 400 motivated students from rural high schools, aged 10 to 16, are currently exploring astrophysics topics through inquiry-based activities together with their teachers. To support their enthusiasm, CosmoAmautas has equipped each one of these AstroClubs with a telescope and 'rural' sky observation kits for all, which consist of planispheres and compasses to locate planets and constellations with the naked eye, without the need for a cell phone or other technologies.

Early indications of positive impact have been already observed, with Astroclubs organising inter-regional measurements of Earth's diameter and presenting in national conferences (ECI 2023), and participating in international measurements of Earth's diameter. Over the next few years CosmoAmautas aims to offer the teacher training workshop and to open new AstroClubs in more regions in Peru, setting a precedent for other countries with limited scientific infrastructure. In the long term we aspire to promote and decentralise the technological and scientific development of the country.

Astronomy Education for all High School Students – Challenges for the Future

Speaker: Hidehiko Agata, National Astronomical Observatory of Japan, Japan

In this contribution, examples of efforts in Japan are presented. We also call for an international survey. In Japan, the high school curriculum national guidelines that came into effect this year still require students to choose from physics, chemistry, biology, and geology (including a little astronomy) as in the past. Currently, only about 30% of Japanese high school students study astronomy. However, in order to solve various problems facing modern society, such as responding to the 3Ss (Socity5.0, SDGs, and STEAM), science, technology, and innovation, maintaining the global environment, and coping with natural disasters. A short questionnaire form regarding high school science curricula in different countries is made available.

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

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How are countries trying to implement "Big Ideas in Astronomy" into school education in the future? "The Astronomy Literacy Goals" is a project by Leiden University (the Netherlands) and Institute of Astrophysics and Space Sciences (Portugal) in the framework of the IAU Commission C1: Working Group on Literacy and Curriculum Development. They published the "Big Ideas in Astronomy" first version in 2020. "Big Ideas in Astronomy" is now a project of the IAU Office of Astronomy for Education (OAE).

In Japan, the high school curriculum national guidelines that came into effect this year still require students to choose from physics, chemistry, biology, and geology (including a very little astronomy) as in the past. Currently, only about 30% of Japanese high school students study a small part of astronomy. However, to solve various problems facing modern society, such as responding to the 3Ss (Socity5.0, SDGs, and STEAM), science, technology, and innovation, maintaining the global environment, and coping with natural disasters, it is not enough to take only some of the subjects that are separated.

With an aim to include in the government curriculum guideline, we attempt to design new curriculum of science education in Japanese high school that smoothly connect from junior high school. Social problems that we face today require interdisciplinary scientific comprehension to be addressed while students learn each science subject independently. Considering the purpose of science education and its role in society, we reconsider compulsory subject for science education that should be comprehensive and foundational to nurture problem solving skills. This work is supported by JSPS KAKENHI Grant Number 22H01071 from 2022 to 2025 and we present our overall plan here.

We started a discussion on the curriculum guideline for the 2030s based on "Recommendations - The Ideal Science Education at High School" from the Science Council of Japan in 2016. Outline

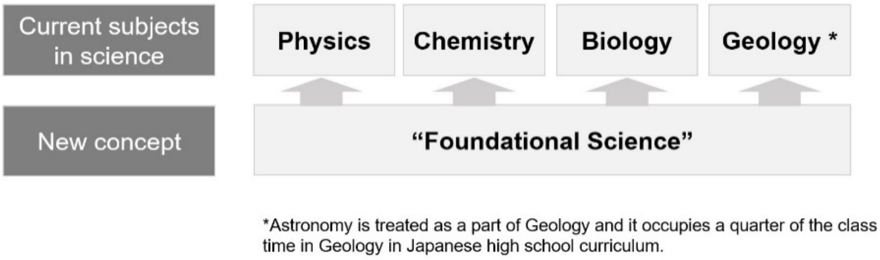

Figure 1: The Concept of "Foundational Science"

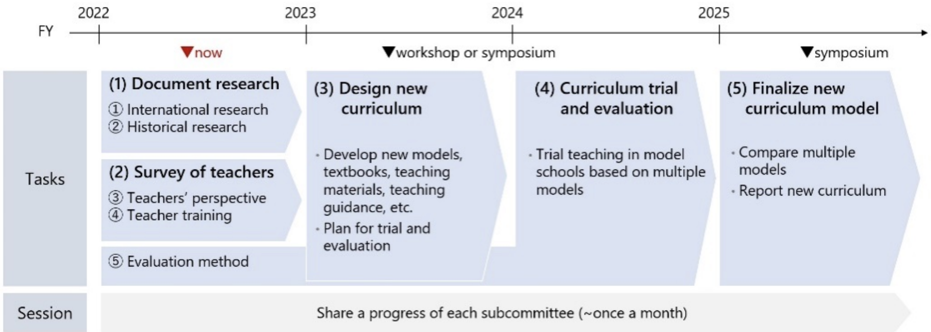

Figure 2: Schedule from FY2022 to FY2025

of the recommendations in 2016 are (I) Science education in high school should be reassessed to nurture problem solving skills under the comprehension of meaning of science and its role in society. Considering current social problems that require integration of knowledge and competency to deal with, content-based learning is not enough to tackle with social problems to be faced in the future. More specifically, the current 4 basic subjects in science should be reorganised into compulsory "Foundational Science*" (*tentative name, Fig. 1). (II) In order to cultivate science literacy for all students in high school, regardless of their choices of the course, 8 units, 6 units at least, should be allocated to "Foundational Science". In addition, to make it feasible, the system of training teachers to enable them to teach any subjects in science in general and the university entrance examination system that requires "Foundational Science" are also needed. But, unfortunately, the concept of the recommendations was not adopted in the government curriculum guideline applied from FY2022.

Therefore, a curriculum study was initiated as a voluntary research group. The research approach taken by our research group is as follows (Fig. 2). In 2022: clarify the issues of science education curriculum in high school on nurturing problem-solving skills under each sub-committee, focusing on current social problems that require integration of knowledge and competency to tackle with. In 2023-2024: design new plans for science education curriculum and execute trial classes and its evaluation. In 2025: summarise our study and recommendations to the council of Central Board of Education aligning the timeline of revision of the government curriculum guideline. Present our recommendations also to the public to spark an interest and account for the public opinion.

It is my personal view, as the principal research investigator, that I would like to install the last chapter of the “Big Ideas in Astronomy”, i.e., the importance of globalism and universalism. It will help students understand the significance of learning science.

Finally, we would like to ask for a favour from you all. We would like to hear about interdisciplinary high school science education in your country. Social problems that we face today require interdisciplinary scientific comprehension to be addressed while students learn science subject separately, physics, chemistry, biology, and earth science, in Japanese high school science curriculum (age: 15 to 18). Considering the purpose of science education and its role in society, we are now discussing a compulsory subject for high school science education. We would be grateful if you would kindly inform us of science education system in your country for the comparison study. Please scan this QR code to answer a short questionnaire.

Discussion summary

Governments, administrations, and ministries of different countries have different educational policies that include their own goals and aims. However, none of them want to be recorded as "last" or "bad" in the grand scheme of things in the world, for example, being recorded as last in mathematics and English scores. Media reports on education have had an impact on the decisions that governments have to make when such critics come out. This usually gets the governments, administrations, and ministries of education attention, making them listen to people working in formal education (teachers, experts). When it comes to science, especially astronomy, this applies too, where we see the ministries gain interest based on the critics and popularisation of science in the media.

In this session, we discussed the role of administrations in formal education, where it is not always easy to implement a new curriculum especially when the administrations are not interested or detached from the everyday classroom practices. From the discussion, it is clear that teachers are the main initiators of change and reform of the curriculum. The experience that the teachers have of the content knowledge, knowledge of their learners, and pedagogy, makes them experts in the classroom. Therefore the ministries and administrations should be listening to what they have to say. The teachers know what works in terms of pedagogy, when they collaborate with experts such as astronomers, their whole package of teaching and learning improves. However, without the other, it poses a challenge, in which context may exist but it is not well taught.

This is the reason why teacher training programs are important, as these enable the teacher to gain content knowledge as well as pedagogical knowledge, together with their own knowledge of their students. Teacher training also gives teachers the confidence to use the available resources in their classrooms. Teacher training also strengthens teachers' collaborations, where teachers are aware that there is available support and that they are not alone.

When ministries, administrations, and governments, see the impact that these teacher training have in education, they are more likely to start investing in them and thus supporting the vision. This is rather a difficult thing to do, but the key is for teachers "not to give up", and to keep challenging the system. It is also important to keep in mind that education is also politically driven, as such the administrations can make decisions based on the current political state. This is why it is important to always show the connections that science and astronomy have to the current situations of the world.

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