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

What Everybody Should Know about Astronomy Education

12 – 15 October, 2021

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

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

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Foreword

3rd Shaw-IAU Workshop on Astronomy for Education

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

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

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

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

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

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

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

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

OAE Center Italy

OAE Center Cyprus

OAE Node Nepal

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

Teaching Methods

Session organiser: Sara Ricciardi,
INAF OAS/Game Science Research Center,
OAE Center Italy, Italy

Session overview

This workshop session is devoted to analyzing teaching methods and practices that can encourage students' engagement and the understanding of Astronomy, Astrophysics and in general STEM disciplines and their methods. For this round of the workshop we decided to focus on primary and junior secondary school levels but we believe our conversations are relevant in general and for learners of any age.

So the first questions we posed preparing this session are: in the school environment how should STEM learning be? How can Astronomy be integrated into that?

We found a common ground in the vast majority of the talks and posters submitted. Some people clearly pointed out that the learning experience should be meaningful and significant, learners should be able to experiment and understand with their own experience. Others suggest the learning should be personal and creative as personal and creative is the work of scientists. Others focus more on a very important aspect that regards the idea of STEM learning and how this is connected with children's lives and worldviews. STEM learning should be for all: we cannot allow the learners to boycott themselves thinking they "are not enough" for science. We also should be conscious that people are different and with different ways to interpret the world; as a community we should provide multiple practices and perspectives. We had 5 speakers from North America (U.S.), South America (Argentina), Asia (Japan), Africa (Tanzania), Europe (The Netherlands) and 5 posters.

Talk contributions

A Creative Learning Approach to Astronomy Education

Speaker: Carmelo Presicce, Lifelong Kindergarten Group, MIT Media Lab, USA

In this talk I will briefly describe the 4 P's of creative learning: Projects, Peers, Passion and Play. Despite being quite simple ideas, applying them to the design and facilitation of creative learning experiences is far from easy. The 4 P's do not define a method or a specific practice: they are guiding principles that help educators ask new questions, challenge assumptions, and inform their practice. I will highlight some current experiences in astronomy education that, in my opinion, resonate with this framework. I hope that the four P's of creative learning can be a useful framework for teachers to imagine and develop meaningful learning experiences, helping their students grow as thoughtful and curious inhabitants of the universe.

Talk link: https://youtu.be/1myaeRk1Oto

At the Lifelong Kindergarten research group at MIT we study how to design technologies and experiences to help young people learn by creating. Our group is well-known for creating Scratch, a free visual programming language that allows everyone to easily create interactive stories, animations and video games [1]. But our research is not limited to developing tools. For us it is important that children learn by making projects that they find meaningful, in collaboration with others, and with a playful spirit.

We call this approach creative learning, and we summarize it with four words that we call the 4 P's of creative learning: Projects, Passions, Peers, and Play [2]. The creative-learning approach is applicable in a wide variety of educational contexts and disciplines. In my talk I reflect on how the 4 P's of creative learning can be applied to design-learning experiences related to astronomy.

Projects: People learn better when they are actively engaged in creating something: a sand castle, a poem, a computer program, or a theory of the universe. [3] How can we engage students in an active and creative learning process? What type of projects or activities can help them encounter some particular ideas, or spark certain questions?

In order to see wonderful examples of active and creative learning in astronomy, I suggest looking at the work of Nicoletta Lanciano and Franco Lorenzoni. In their books [4][5] they describe activities in which children make observations and drawings of celestial bodies to track their movements over time; manipulate object or construct physical tools to measure angular distances in the sky; explore myths and traditions from different cultures in the world, and collaboratively write their own myths about the creation of the universe. All these activities allow students to encounter and generate new knowledge through concrete objects and creative experiences.

Passion: When people are engaged in an activity that they find interesting and meaningful, they are more likely to work harder and persist when they face challenges. But although some children might be already fascinated by stars and planets, others might see astronomy as something too far from their life, or simply not for them. How can we design activities that are engaging for everyone?

One way is to make the activities more concrete and closer to their lives. For example, Lorenzoni and other educators organize the "first night of school", bringing students outside to observe stars and planets, sharing stories and questions. It is easy to imagine how exciting it can be for students to meet outside at night, and how this experience can get many of them curious about the sky and what is out there.

Peers: Learning flourishes as a social activity, since people are engaged in sharing ideas, collaborating on projects, and building on each other's work. Learning together can take different forms, from big group discussions to small group collaborations, from sharing feedback to remixing other people's ideas. In such collaborative, peer-to-peer environments, teachers act as facilitators and play a wide variety of roles, sometimes guiding the exploration, other times responding to questions, other times acting as connectors among the students.

I recently participated in an online workshop called "Incontriamo i Cieli del Mondo" organized by Nicoletta Lanciano, Néstor Camino and other astronomy educators, involving participants joining from different continents and latitudes. The workshop fully leveraged the cultural and geographical diversity of participants: we shared myths and traditions linked to astronomical events in our local cultures, we made observations of the Moon from our window at different times, and shared drawings and pictures with others, discussing analogies and differences, and making discoveries that none of us could have done alone.

Play: The most engaging type of learning involves playful exploration and experimentation: trying new things, tinkering with materials, testing boundaries, taking risks, iterating again and again. What type of activities can engage students in an iterative, exploratory, experimental style of learning?

It might seem hard to imagine ways to playfully experiment and iterate quickly with astronomical knowledge, especially when direct observation is involved. But sometimes technology can help. For example, with softwares like Stellarium [6] everyone can simulate the sky from anywhere on Earth at any specific time, make time flow faster or slower, and zoom in on objects as they would with a very powerful telescope. It is definitely not as fun as being outside and watching the sky, but these tools provide unique opportunities to students to experiment and tinker with the sky.

The four P's of creative learning might seem quite simple ideas, but the practice of designing and facilitating creative learning experiences is far from easy. Projects, Passion, Peers, and Play do not define a method or a specific practice: they are guiding principles that help us ask new questions, challenge assumptions, and inform our practice as educators. I hope that the 4 P's of creative learning can be a useful framework for teachers to imagine and develop meaningful learning experiences for their students and help them grow as thoughtful and curious inhabitants of the universe.

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Astronomy Education as a Means to Transform our Worldviews

Speaker: Néstor Camino, Complejo Plaza del Cielo - CONICET-FHCS UNPSJB, Esquel, Chubut, NAEC Argentina, Asociación Argentina de Astronomía, Argentina

The way we see the world is a construction whose characteristics are historical, cultural, social, psychological and strongly associated with teaching and learning processes, mainly through formal education and outreach. We will discuss what elements the actions of Education in Astronomy should have to contribute to the construction of solidarity world views, respectful of diversity and modern in terms of the relationship of human beings with the sky in our time, with projection to a future in peace. and social harmony, linked to the sky.

Talk link: https://youtu.be/tE612QF6Jys

It is possible to define Astronomy, in the broadest possible sense and from the very beginning of human times as one of the cultural forms of civilizations to relate to the sky. In a much more restricted definition, both due to its specificity and its temporality, Astronomy would be a modern activity specialized in building and validating scientific knowledge about the Universe. This last definition is included in many ways in the first one, however, both of them imply that people and human groups build a certain view on ourselves and of the universe that includes us. Furthermore, we can assume that human beings have always built "worldviews" (or also "cosmovisions"), whose main function would be to provide a way to interact and give meaning to natural and social world, whose characteristics are idiosyncratic, historical and cultural, being so broad that they integrate all the aspects that constitute life, individual and social, one of them the sky. In this very complex process, Education, also in the broadest possible sense, is one of the main factors involved in the construction of a certain worldview, both of individuals and of groups.

What can we share in the field of Astronomy among educators from China, Latin America, Africa, Germany, etc.? We do share the key elements of the scientific discipline of Astronomy as a normal science in the present epoch, in kuhnian terms; in other words, we share the constitutive elements of the present paradigm, being built through at least a few centuries. Elements, such as, the ideas of Copernicus, the expansion of the universe, the nature of light, and gravitational waves, observing with the naked-eye or via hyper technological multi-frequency resources, and much more. The dominant paradigm is a strong structure omnipresent, among others, in books, universities, and schools. So, there are not serious differences about those paradigmatic constituents among text books, resources, curricula structures, in those places all around the world. That is because when we teach, what we teach are mainly those paradigm components. We can share, we should share, the fundamental characteristics, theoretical, methodological, even its critics, of the dominant paradigm of what we call Astronomy. But, this is just useful for the Teaching of Astronomy, it is not enough for Astronomy Education.

As scientists, we can affirm that we share a paradigm, in the historical context of our scientific discipline: Astronomy. But people do not live inside paradigms, they (each one of us) live inside worldviews. Sometimes, those worldviews include elements of scientific paradigms: from Astronomy, Biology, Physics, etc.; many other times, they do not. We must remember that it is totally possible to live without a scientific paradigm, even without elements of a scientific paradigm, but it is not possible to live without a worldview.

Astronomers construct paradigms in the small scientific community they belong to and in which they investigate; educators contribute to the construction of worldviews with those who are being educated in a much extended, non-professional and open global community. But worldviews not only are constructed by formal education, which should include elements of those scientific paradigms, they are constructed gradually and continuously from the birth, through other types of education, by religion, family and groups, by social representations, etc., in an even more informal and complex process through the entire vital cycle.

In the broad field of Astronomy Education, we are mainly educators, not just astronomers!!! So, we must consider that Astronomy Education is much more than Teaching of Astronomy, and must be conscious that Astronomy Education is immersed in the whole process of Education, in which the respect for identities, interests and idiosyncrasies must be fundamental, like in the case of worldviews.

It is just the strong idiosyncratic nature of worldviews that must be taken into account when we design any proposal to develop proposals on Astronomy Education, mainly in formal educational systems. When we educate, we do it in aspects of life much more diverse and profound than in a restricted area, whose relevance is no doubt fundamental to our scientific paradigm but that could be irrelevant to everyday life. If we speak of "Astronomy for Education", we must put each of those key elements of the present, complex, and highly specialized astronomical paradigm in a transposition process to create many and diverse educational actions for everyone, not restricted to certain groups of age, gender, capabilities, interests.

It is the Didactics of Astronomy, the most specialized tool that we have to assure that we are really educating through Astronomy, the main goal of Astronomy Education and Astronomy for Education. It is through Didactics of Astronomy that we should accomplished that didactical transposition, to develop myriads of proposals than contribute in a significative way to the construction of worldviews that include the sky among its multiple elements, both in its cultural diversity as from a conception of scientific knowledge.

Didactics of Astronomy means that we take into account the way people learn, more than the way teachers teach; we must think more in terms of learning than teaching, if we want to bring scientific elements to the complex structure of a worldview. Such construction process of scientific elements to be included in worldviews means, among many other aspects, the ability to wonder about what is perceived and to problematize the supposedly validated knowledge, the ability to see differently, to imagine other explanations, different ways to possible futures, actions that will gradually modify the dominant worldviews of the group itself and of the epoch, inside and outside the restricted field of Astronomy as a science.

Furthermore, if we analyse the curricular designs of formal education in our countries, especially at the secondary level, we must ask about the presence and characteristics of Astronomy in them. What paradigmatic elements of nowadays Astronomy are really present in formal education? In which ways are they transposed in order to assure they are being subsumed in a broader, more vivential and significant personal and social worldview, historically and culturally contextualized? Are there actual adequacies of Astronomy concepts and methodologies according to cultural differences? Is there any discussion of Epistemology of Astronomy, in order to comprehend the complex process of scientific knowledge construction, very different to common sense knowledge which is actively present in worldviews? Are there elements of Nature, Science, and Astronomy in those formal curricula? Is there a discussion about social relevance of scientific development and its relationship with, e.g., technology, society, environment, human rights, ethics, life, and what is the role of Astronomy in those items? These are some of the questions we must find answers to, as soon as possible, not only from Astronomy but from Astronomy Education.

It is usual that when planning an educational action, we carry out a diagnosis of previous or alternative ideas, in order to "know the student", as meaningful learning requires. But from the perspective of Astronomy Education as a means to contribute with scientific elements to enrich and diversify personal and social worldviews, that approach is no longer satisfactory. Alternative conceptions are, we must think of them, as the small tip of a huge iceberg. The iceberg is a worldview, but we only perceive and conceptualize the tip. People learn in a much more complex way; people learn through their worldviews, which are always present, and constitute an epistemological structure, much more than a few alternative conceptions. Even more, most of the time, worldviews do not match scientific paradigms, so it is a mistake to think that we can teach without knowing or without taking account of the fact that people see the world in many different ways than the one we want to teach. Astronomy Education must be more significant in the future than simply teaching Astronomy, if we want people to live their worldviews including scientific elements.

Astronomy Education, Astronomy for Education, must be a dynamic and professional activity, developed by specialists who must be aware of the relevance of worldviews. An activity respectful of the diversity and identities of human groups, with deep roots in scientific knowledge, with a vision of the future but with awareness and respect for the past, with rigor as well as epistemological humility, and conscious of the ethical responsibility that concerns us as scientists and educators towards the society that we integrate and that we collaborate in the construction of more genuine ways of seeing the world.

We must be aware that every time we educate in Astronomy, we bring to people new elements to transform their worldviews. It is not an invasive way if we design the didactical structure thinking in "him", in each one of the learners; it would be invasive, imperialistic, totalitarian, if we teach the same, independently of in which part of the world and with what people we will work. We would be only teaching components of a scientific paradigm; we would not be educating through Astronomy.

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What all Teachers Should Know about Astronomy Education in Primary and Lower Secondary Education

Speaker: Akihiko Tomita, Wakayama University, Japan

Contents of school education are defined by curriculum standards in each country or territory. Though it is not easy to meet all the demands, the standards are based on years of discussions, therefore, the standards indicate what all teachers should know; we already have the answer. On the other hand, there are difficulties teachers face in teaching astronomy. Based on papers and interviews with teachers about their work in Japanese classrooms, I will present what general teachers in Japan want to know about astronomy for their teaching work. The presentation focuses on primary and lower secondary education because many teachers in the levels are not always well versed in astronomy, therefore, what they want to know indicates what all teachers should know from the perspective of teachers.

Talk link: https://youtu.be/0ABERfDdU_4

Astronomy is popular among all ages. Students are crazy about black holes, extraterrestrial intelligence, space missions, and many others. Social capital for astronomy education is abundant. In Japan, more than 350 planetariums are open to the public in all areas including rural areas, more than 200 thousand projections are made a year, and more than 8 million people visit there a year. However, when it comes to school science classes, both students and teachers are not good at the content. Except for a few teachers who are good at astronomy, many teachers have a hard time teaching astronomy. This presentation is a summary from a teacher's point of view, not a student's point of view. Thus, the first research question was set like this: What do teachers who are not good at astronomy have trouble with in their classes?

Method: First, build relationships with the teachers and then proceed with the interview. Then, collaborating on actual classroom planning based on this research. If we just list the problems, it has already been done in many research publications. If this is all we do, it will be reinventing the wheel. Today, my presentation is the first result of the interview.

Preliminary results: These are some feedbacks from preliminary interviews. The first is the difficulty in direction and location. "*The students need to think about the direction, time, position of the Sun, and phase of the Moon at the same time. But these topics are not so rooted in students' daily lives.*"

Some surveys have shown that thinking about positional relationships is linked to ability in mathematics rather than science. This is also connected to map-based learning in social studies. Cross-curricular teaching and STEAM education are now very popular among science education as well as astronomy education. I believe that advice from this perspective would be very useful for teachers who are not good at astronomy. Not only math and technology, but astronomy education can also be linked to history, geography, literature, art, craft, music, health education, moral education, and international understanding education.

Next is the issue that experimentation can lead to misunderstanding. *The textbook says, "The phase of the Moon changes because the positions of the Moon and the Sun change." However, many students think that this is due to the change in the positions of the Moon and the Earth from the experiment of looking at a lighted ball, and I do not fully understand this.When I tried to show a quarter moon and a crescent moon in the experiment using a ball and a light, I moved the position of the light, which made the students think that the position of the Sun also changed.*

This is a great opportunity. Rather than being pessimistic about getting the wrong concepts and the confusion, here is an issue that needs to be carefully researched: what students looked at, what students thought, what students concluded, what students were confused about, and what students came up with. Rather than whether it was correct or not, we should encourage students' way of thinking. We can then make a new class plan based on the above investigation. There are a wide variety of ideas as to what causes the phases of the Moon. Some science education researchers may just be disappointed to see the results of such a survey. Rather, we should investigate what kind of moon the students see in their daily lives, no matter how ridiculous it is, how they interpret it, and how they connect their interpretation to the moon they actually see. Primary and lower secondary school teachers are good at such investigations and would also enjoy doing it, regardless of whether they are good at astronomy or not.

In a classroom that nurtures the thinking ability, thanks to the classroom teacher's great PCK, students are going to the next step to explore further. *As the students' understanding of the Moon phase increases, a new question arises: "Why does the Moon move like that? This is a question that is not related to the textbook description. How should I respond to such a question?* This episode shows the new next step after "what about this kind of material," and "what about this kind of teaching method?" The teacher was very confused. Of course, it is not true that this kind of comment by a student is a getting-off subject just because it is not written in the textbook. First, researchers in astronomy education can appreciate the teacher's high-level classwork. How to respond to students' high curiosity is not easy, of course. Not by just transferring knowledge, but by creating a new exciting environment based on the students and the class atmosphere, this is a new issue for joint research between researchers and teachers.

This presentation is the first result of some interviews, so please wait for some time to show the result of the whole research. Instead of that, here I would like to introduce a new project to exchange and discuss together about the difficulties the teachers have faced in school classes and how they have motivated students, created a cheerful class, and brought out students' thinking ability and scientific views. For teachers who are not good at astronomy, we should not just dump knowledge and provide physical materials, but also share ideas that will make the teacher feel positively, "What? This is the kind of classroom creation I am very good at!" or "Wow! This is the kind of classroom creation I can do from now on!"

My colleagues and I are preparing a project called New Astronomy Day in Schools as a platform, which will host this project. The website will be accessible in September.

Challenge in Teaching Astronomical Causes of Seasons in the Tropics

Speaker: Noorali Jiwaji, Open University of Tanzania, Tanzania

Tropics, especially close to the Equator experience mild changes of temperature during the year, so seasons are marked primarily by the bimodal rainfall pattern, which is broken by proximity to ocean, resulting in weakly defined seasonal changes. Astronomical causes of seasons are taught using the northern "gospel" of summer, winter, autumn and spring without understanding the regularity and profound seasonal changes experienced away from the tropics. Hence the local seasons as well as its astronomical causes are not properly understood and misconceptions and wrong ideas are introduced at a young age. We show how this problem is reflected in Tanzanian learning, especially when local language (Kiswahili) terminologies are used to describe seasons.

Talk link: https://youtu.be/oRmpIR4eIME

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Astronomy is taught in schools primarily as a science subject, in particular, Physics. It is also taught as part of Geography for its influence on weather and seasons under the Solar System topic with additional topics such as eclipses, tides, remote sensing are also included.

Tanzania has a colonial legacy from millennia with Arab traders trading with dhows to the eastern African coast making use of the Monsoon winds and navigating using the stars. The Arab and Bantu culture assimilated to produce the Swahili culture and the Kiswahili language that is now used across east and central Africa. The German rule from 1880's and the British Protectorate from 1916 imposed foreign culture and provided education for clerical jobs requiring rote learning that is practiced to date. Teaching materials used today are derived from colonial materials.

Teaching in Schools: In Tanzania Astronomy topics are introduced in Primary school in Standard 3 (Grade 3) (TIE, 2019b). The local Kiswahili language used as a medium of instruction introduces misrepresentations from translations done by authors not familiar with Astronomy. This has also introduced a big confusion in planet names, in spite of the rich Kiswahili Astronomy terminologies from ancient sailors compiled recently by Knappert, 1998.

In Secondary schools, where the medium of instruction changes to English, Astronomy is included as a chapter in Physics with a previously weak chapter (TIE, 1996) that included misconception, which has how been included in a more thorough chapter on Astronomy at the very end of the new Physics textbook (TIE, 2019c). The inexperience of teachers in Astronomy glosses over the topic and students have to learn it by rote. In Geography, the Solar System topic is introduced in Form 1 (Grade 8) and Form 2 (TIE, 2019a) with a focus on the four standard seasons using 2D diagrams to show a 3D system with Earth's axial tilt not easy to understand how the four seasons arise. Misconceptions such as "the North Pole faces the sun directly" and wrong explanations such as "temperatures are hot due to long duration of sunlight" confuses the learner further. The standard four seasons of Summer, Winter, Autumn and Spring are explained without any association with local experiences of the climate. Close to the Equator only two prominent seasons can be experienced: Hot and Rainy. Elsewhere in the tropics such as in Tanzania (1oS to 10oS), a bimodal rainfall pattern gives three main seasons: Hot, Short Rains, and Long Rains which cause wide local variations due to relief and ocean.

Study on understanding of Astronomical connection with seasons: Knowledge and understanding of the four standard seasons and its relation to Astronomy for the annual cycle was studied using a questionnaire. True and False options were provided together Do not Know and Do not Understand options were also given. The questionnaire was distributed to nearly 200 Secondary school teachers and adults for online responses and by hard copy to nearly 200 Secondary school students from different schools across Tanzania, who had passed through the seasons topic in their Geography classes. Even after several reminders and urging, only 10 responses were received from adults including teachers. However, responses from 170 students were received.

Lack of understanding: Lack of responses from adults is seen as a reluctance to show their lack of understanding long after they left school. However, the results obtained from students were useful. Though Summer was well connected (90%) with the hot season, the other three seasons were not as well known. Questions about the time of year for each of the four standard seasons showed a wide range from January to December for all seasons, although they know the time for long rains. The cyclic nature of the seasons was understood by about half the respondents. Cause of hot temperatures was well connected with decrease with altitude, but there was a misconception (70%) about the closeness of the Sun to Earth even at Noon as causing it to be hot.

Our study shows that among students there is a lack of understanding of the four standard seasons and their astronomical causes. To alleviate this problem special in-service training of teachers is needed urgently which has begun in collaboration with experts from the Network of Astronomy School Education (NASE). Two training sessions have been held and more are planned. Corrections of school texts are being pursued for local Kiswahili language materials in Primary schools and producing radio programs for the public. Creation of the Astronomy lexicon related to its concepts will benefit a wide population across eastern and central Africa. Secondary school Geography textbooks also need to be corrected and improved to include local climate variations; with the four standard seasons being stressed to be for high latitudes and use their clear demarcations to show the cyclic Astronomical nature of seasons. Clear understanding of how local seasonal effects can be understood will be essential to prepare the public for the expected climate changes to be tackled.

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Challenge-based Learning for Astronomy Education

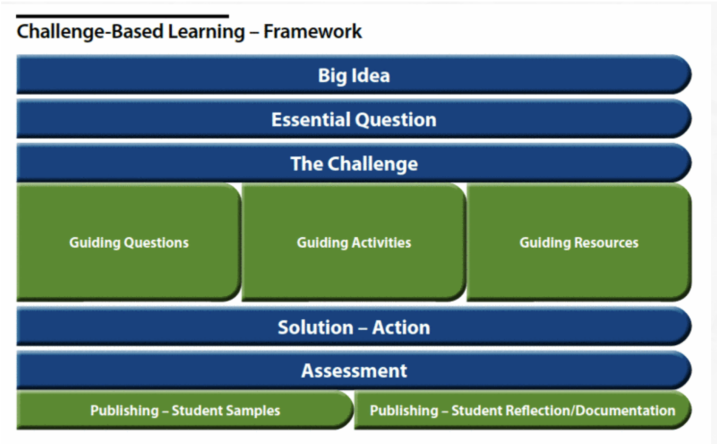
Speaker: Jasmina Lazendic-Galloway, TU/e innovation Space, Eindhoven University of Technology, Netherlands and School of Physics and Astronomy, Monash University, Australia

Challenge-based learning (CBL) has emerged in the last decade as a response to the complexity of problems facing society in the 21st century. This way of learning prepares students for the future of multi- or inter-disciplinary work and decision-making, with emphasis on self-awareness and teamwork, among other things. Students work on complex open-ended projects, often directly related to societal challenges in collaboration with "challenge owners" such as government or societal organisations, university researchers or industry. CBL has been applied for learning in high-schools, universities, companies and scientific organisations such as CERN. I would discuss ideas how one could use CBL to tackle societal issues through astronomy education.

Talk link: https://youtu.be/jwD-xCSR_c0

How to use challenge-based learning to tackle societal issues through astronomy education?

Challenge-Based Learning (CBL) has emerged in the last decade in response to school students' disengagement in classes and desire to provide them with more challenging coursework that is linked to real-life context (Apple Inc 2009). CBL involves active participation and collaboration with experts across different levels (teachers, industry, community members) in order to foster deeper learning and where students can come up with ideas of how to make a difference. While it has been extended further to higher education and work-based learning to tackle the complexity of problems we face today in society and workplace, the fact that CBL requires exploration of topics from multitude of perspectives and disciplines makes it suitable as a learning approach at any level. I would discuss ideas on how one could use CBL approach to tackle societal issues through astronomy education, starting with one of the topics from Big Ideas in Astronomy "We must preserve the Earth, our only home in the Universe".



Apple's Framework for Challenge-Based Learning

An example: Big Idea: Light pollution and its effect on humans and other living organisms. *Generate "essential question"*: What is the impact of light pollution on human life and human activities such as astronomy? *State the challenge*: Increase awareness. Create opportunities for dialogue between the key players. Create ideas for technical solutions. Create ideas for societal solutions. *Design process - Guiding questions/activities/resources*: Students identify the knowledge they will need to understand to develop a solution to the challenge, e.g.: What is light pollution caused by? What are the issues/barriers in changing the current practices? Identify activities needed, e.g., conduct experts surveys, make games, do calculations etc. to acquire the knowledge needed. Identify resources needed, e.g., podcasts, websites, videos, databases, contact information for experts. *Identify solution/action*: For example, make a campaign to inform and/or convince family, peers, or community members about the need for change. *Assessment (publishing/reflections)*: For example, students document their experience using audio, video, and photography and can be provided with a series of prompts for final reflections about what they learned about the *subject matter and the process*. Students can share their findings with everyone online, or at a school event with other students and/or the whole community.

The Significance of Doing Practical and Experimental Astronomy

Presenter: Carles Schnabel & Rat Parellada[1], Planetari Fora d'Òrbita and Observatori Astronòmic Garraf, Spain

Astronomy is explained in an encouraging but theoretical way. They provoke sensations of admiration in the face of violent and spectacular phenomena. Their meaning is seldom understood and contextualized. We need to raise questions about things we can see, instead of giving answers about what we never see with our own experience. Everyone has access to the sky and his movements. Main stars are easily observable and measurable. You can experiment with your own body and simple materials. Once the basic concepts are well established, we will be able to face them with the guarantee that the receiver will want to achieve a clear and contextualized understanding of the concepts of the physics of the universe.

Poster link: https://youtu.be/8UuZFDLPb_Y

Astronomy is usually explained in a very theoretical way. This approach can be very exciting. Kids and teens love to learn more about the Big Bang, black holes, galaxies, exoplanets, Martian rovers, and more. However, it is a knowledge that, with a few exceptions, remains very superficial in the receiver. They provoke the characteristic sensations of admiration in the face of violent, spectacular and large-scale phenomena. But their meaning is seldom understood and contextualized. They are "out-of-place" knowledge.

But astronomy admits of a much more practical approach, from the receiver's own experience. Everyone has access to the sky: all the world's population, all cultures, all ages, and all genders. The movements of the sky and the main celestial objects are easily observable and measurable without even the need for instruments. The observation of the Moon and the Sun, for instance, occurred thousands of years before the establishment of calendars.

This allows you to practice astronomy with your own body and with simple materials from the immediate environment. This type of practical astronomy, which can be done both day and night, is at the bottom of cognitive processes. Once the basic concepts are well-established, we will be able to face them successfully and with the guarantee that the receiver will want to achieve a clear and contextualized understanding of the deepest concepts of the physics of the universe, in astronomy. We need to raise in the receiver the questions about the things he can touch and see, instead of giving him answers about what he has never seen with his own experience.

[1] https://planetari.cat/

We propose to mark some footprints in the school yard: North-facing footprints are used to observe the shadows of the sun throughout the day and at different times of the year. Other south-facing footprints are used to observe the positions and phases of the Moon throughout the month and throughout the year. The meridian (line from north to south) and the parallel (line from east to west) drawn on the ground are used to compare the shadows that occur on the ground with those that are drawn on a globe.

With these simple resources, questions will be generated such as: Why do the Sun and the Moon always move in the same direction? Why do the Sun and the Moon change in height during the day, throughout the month, or throughout the year? Why is the Moon not visible always? Why is it sometimes seen in the morning and sometimes in the afternoon? And so on. They can be invited to continue with similar observations at home, with their family, to observe the movement of the night sky: stars and planets. This simple observation of the sky will raise a lot of questions about distances, type of stars, how are they distributed in space, etc. This is only an example. Other ideas we worked out can be seen at `https://tuit.cat/tVx9q`. These are catalan spoken videos, but they are also subtitled in English.

Astronomy Education Outreach with Younger Community through an Online Service-Learning Approach

Presenter: Othman Bin Zainon, Department of Geoinformation, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

Astronomy involve concepts that related to everyday phenomena. Astronomy is also about the science of celestial observation and evaluation involving celestial objects that happened outside the earth's atmosphere. In Malaysia, astronomy topic has been adapted in various of school levels especially in science and mathematics syllabus. However, some of the younger communities' have problem in understanding about the basic concept of astronomy. Therefore, Universiti Teknologi Malaysia Astronomy Co-Curricular students have carried out an online Service-Learning approach for transferring the astronomy knowledge to the younger students. This innovative astronomy service-learning approach consists of five activities namely Astronomy Talks, Demonstration, Hands-on, Quiz and Competition.

Poster link: `https://youtu.be/o_xxZBbj3tw`

Astronomy is about the science of celestial observation and evaluation involving celestial objects and events that happened outside the earth's atmosphere. In Malaysia, astronomy has been adapted as one of the subtopics in various school levels starting from kindergarten, primary school, and secondary school especially in science and mathematics syllabus. However, some of the younger communities' have problems in understanding the basic concept of astronomy. Therefore, Universiti Teknologi Malaysia have designed an Astronomy Co-Curricular course for the university students. In the pandemic situation today, the students must carry out an online Service-Learning to transfer the astronomy knowledge to the younger students.

Service-learning pedagogies combine learning goals and community service in ways that can enhance both student growth and the common good (Bandy,2001). Service learning is a combination of teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities". The objectives of this project are to increase understanding of the concept of astronomy to the younger students and to increase the younger student's interest in science through astronomy knowledge transfer. This study illustrates five innovative astronomy activities that used to enhance the learning potential of service-learning pedagogy. The five activities are Astronomy Talks, Demonstration, Hands-on, Quiz and Competition.

Before the Covid-19 pandemic, the service-learning program was conducted face to face at the chosen community. Now, because of the Covid-19 situation the program was conducted through a social media online platform. A few programs were organized by the astronomy co-curriculum course students.

A pre-survey was conducted before the online outreach program started. The result shows that more than 60% of respondents do not understand the knowledge of the astronomy presented topics. After the online program a post survey was carried out and the results showed that more than 80% of respondents have the knowledge of astronomy topics presented to them. In conclusion, the systematic planning of activities using the service learning approach and five innovative activities can help the young community to understand and enhance their knowledge in astronomy through a selection of a few selected topics.

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Teaching Undergraduate Astronomy Classes with Active Learning Strategies

Presenter: Newton Figueiredo, Universidade Federal de Itajubá, Brazil

Active learning methods have been successfully used to teach science, technology, engineering, arts and math (STEAM) subjects at all levels of formal education. In this talk I will show what can be accomplished by combining three of these methods - flipped classroom, just-in-time teaching and peer instruction - to teach astronomy to undergraduate students enrolled in STEAM courses. I will also present effective ways the instructor can use, under this approach, to assess the students' learning without written exams.

Poster link: `https://youtu.be/MTihpq5l2Bs`

Active learning methods have been successfully used to teach science, technology, engineering, arts and math (STEAM) subjects at all levels of formal education (e.g. Crouch & Mazur, 2001; Freeman et al., 2014). Those methods comprise a wide range of different approaches that have in common the search for an active role for the students in the teaching-learning process, as opposed to a passive posture that characterizes lecture-based teaching (Bonwell & Eison, 2001).

Although each of these methods has been developed independently, the literature reports positive results for the combined use of more than one active methodology in real classroom situations. Araujo and Mazur (2013), for example, present a successful application of peer instruction and just-in-time teaching in higher education. Furthermore, the use of active methodologies in higher education institutions has been shown to be an effective strategy to reduce dropout rates and significantly improve student learning (e.g. Watkins & Mazur, 2013). The effectiveness of this type of approach can significantly increase when face-to-face teaching is associated with Information and Communication Technology resources (Hogarth, 2009).

We have been combining three of these methods - flipped classroom (Abeysekera & Dawson, 2015), just-in-time teaching (Novak et al., 1999) and peer instruction (Mazur, 1997) - to teach an introductory astronomy course to undergraduate students majoring in meteorology, physics and chemistry at a research university in Brazil since 2017. Before class, students are assigned tasks such as watching a video, running a computer simulation or answering a quiz in the virtual learning environment. During class, they have peer instruction classes and problem-solving group activities. After class, they are assigned hands-on activities. All tasks are assessed by the instructor or by their classmates, but there are no written exams.

A quantitative analysis of the interaction among the students in each peer instruction session is performed by means of a binomial test (Figueiredo & Figueiredo, 2019), and also by a comparison of the overall class score before and after the interaction. These analyses show a significant increase in student learning when combining flipped classroom, just-in-time teaching and peer instruction (De Paula et al. 2021).

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The Transferential Relationship from the Discourses between Children and Monitors in an Observatory

Presenter: Gleici Kelly de Lima, UNESP / Bauru, IFC / Rio do Sul, Brazil

The main purpose of this research was to interpret the discourses of the transferencial relations between children and monitors teachers in an astronomical observatory. Were concepts of transference and discourse is introduced highlighting the psychoanalytic aspect as reference to understand the teacher-student relation, during a class visit in an astronomical observatory. Is theoretically and methodologically based on Education, Psychoanalisys and Astronomy Education references. The results obtained by the analysis of the four lacanian discourses of the unconscious point to traces of three approaches to the discursive transferential relationship between monitors and children at the observatory: authoritarianism, excitability and otherness.

Poster link: https://astro4edu.org/siw/p75

The main objective of this research was to interpret the transference relations discourses between children and monitor teachers of an astronomical observatory. Introducing the concepts of transference and discourse [1], highlighting the psychoanalytic aspect as a reference to understand the teacher-student relationship, during a class visit to an astronomical observatory. The focus of study was the Didactic Observatory of Astronomy, "Lionel José Andriatto" at Unesp in Bauru, São Paulo, Brazil. The speaking subjects of this research are children in early childhood education, who visited the observatory, as well as the teacher assistants who guided the visit. Data collection was made through observation, using audiovisual recording and records in a field diary, later transcribed, so this study is based on qualitative fieldwork [2].

In Lacanian theory, language is an independent system that binds people together. In addition to being an instrument of human control, it is the structuring of social ties, a wordless mode of social engagement. In Lacanian theory, discourses are ways of using language as a social link, building on the signified part of the sign that produces the discourse. As discourses are unconscious and wordless, the signifiers in them represent sound, since language is composed of sounds. When these signifiers are articulated, they produce what Lacan calls meaning [3]. We started from this assumption using the metaphor of Lacan's theory of four unconscious discourses: the Master's, the University's, the Hysteric's and the Analyst's, helped us to interpret the discourse and attain, even partially, the understanding of the transference relationship between teacher assistants and children.

Using Lacan's four discourses in our final analyses made it possible to find traces of transferential engagement between the subjects. These findings allow us to define at least three approaches that outline the demands of children and assistants. First, we have the Authority Approach, paving the way for a more Cartesian, dogmatic relationship, and promoting literacy through the "clear ideas" of science, constantly demanding answers from children. Second, there is the Excitability Approach, which relies on the hysteric's discourse, with a more meaningful transference, grouping children together under the rhetoric of astronomy, exciting, and urging them to seek knowledge, proposing questions and encouraging their participation. The third is the Alterity Approach, which describes a relationship more concerned with the construction of knowledge in the other, as when the assistants invested more in encouraging children to speak, enabling a scientific literacy that considers alterity.

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Scaffolding from Astronomers: Delivering Lessons to Schools and STEAM Education

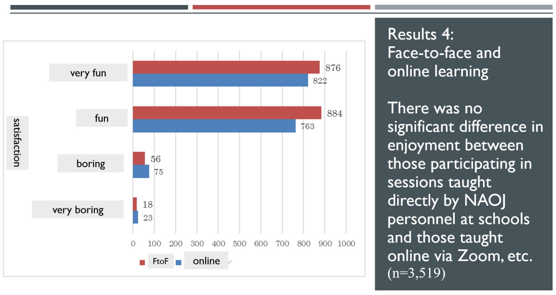
Presenter: Hidehiko Agata & Tokiko Fujita, National Astronomical Observatory of Japan, Japan

National Astronomical Observatory of Japan (NAOJ) launched the 'Fureai Astronomy' education and outreach program in 2010. This is an activity in which NAOJ staff members give classes on stars and universe at elementary and junior high schools, with the aim of getting to know each student individually. In the 2020 fiscal year of the Corona pandemic, in addition to the traditional delivery of classes to schools, online classes using Zoom, etc. were also conducted. In the case of online classes, it is possible to participate from outside Japan. In addition to a discussion of the differences between face-to-face and online, this talk will present examples of scaffolding from astronomers that can be expected to lead to STEAM.

Poster link: https://youtu.be/_Q16-XFuYE0

"Fureai (=Friendly) Astronomy" (https://prc.nao.ac.jp/delivery/) is a NAOJ outreach project that started from a single idea: What interesting reactions might occur if children had

Face-to face lecture-type vs Zoom online



Face-to-face (FtoF) vs online learning

the opportunity to meet actual astronomers? 2021 will mark the twelfth year of its implementation. Due to the COVID-19 pandemic, in 2020 we conducted online sessions in addition to our customary in-person sessions. Hosting online sessions allowed international participation, so we were able to hold 99 sessions in total (69 domestic and 30 overseas schools), with 64 NAOJ's astronomers serving as instructors.

There was no significant difference in enjoyment between those participating in sessions taught directly by NAOJ personnel at schools and those taught online via Zoom, etc.

Participant satisfaction increased in classes with easy-to-understand content and an appropriate level of excitement. The higher the prior interest in astronomy, the more it increased after implementation (prior guidance is important). Satisfaction (fun) and change (increase) in interest showed positive correlations with difficulty (easy-to-understand). Small class sizes tended to increase satisfaction.

90% of children and students want to engage with astronomers again. Please consider implementation at your university or facility. The "Fureai Astronomy" has inspired into the IAU's "Meet the IAU Astronomers!" (https://www.iau.org/public/meettheiauastronomers/).

Discussion summary

Néstor Camino and Carmelo Presicce, our invited speakers, set the stage; Carmelo helped us to connect with the experience of the Lifelong Kindergarten group at MIT Media Lab; he opened a reflection about how to cultivate creativity in STEM learning through learning communities connecting with Astronomy learning practices. Néstor discussed Astronomy Education as a means to transform our worldviews pointing out how Astronomy Education - through a connection with the physical sky - could contribute to the construction of world views based on solidarity, respect of diversity to prepare for a peaceful future. Akihiko Tomita interviewed teachers in Japan and he highlighted the teacher's perspective on STEM teaching/learning and possible criticalities. Noorali Jiwaji discussed his experience in Tanzania where seasons are taught as in Europe despite the fact people cannot observe such seasons. Jasmina Lazendic Galloway talked about a particular way to interpret change in STEM learning: Challenge-based learning (CBL) describing ideas how one could use CBL to tackle societal issues through astronomy education.

The discussion was very lively and engaging. We realized that we are facing similar issues in different countries but also across disciplines (e.g. astronomy and computer science). We also realized there are so many interesting and diverse practices in teaching and learning in Astronomy; the general conclusion of this session is that in the knowledge society, it is a matter of democracy to allow children to connect with science, to develop their own ideas, and to act in our society as an active citizen. This global network of goodwilling people can really make a difference nurturing this community, cultivating personal practices and sharing them with the broadest community. This network has an important role: to help people (teachers in particular) to connect and to share ideas, cultivating a stronger and more connected community.

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