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

What Everybody Should Know about Astronomy Education

12 – 15 October, 2021

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

Publications of the
IAU Office of Astronomy for Education

Compiled & Edited by:
Asmita Bhandare, Giuliana Giobbi, Colm Larkin, Rebecca Sanderson, Eduardo Penteado, Niall Deacon, Gwen Sanderson, and Anna Sippel.

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

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

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

Contents

Organizing Committees

Local Organizing Committee:
Asmita Bhandare, Suresh Bhattarai, Niall Deacon, Theo Dimitrakoppoulos, Natalie Fischer, Giuliana Giobbi, Celine Greis, Esther Kolar, Colm Larkin, Tshiamiso Makwela, Carmen Müllerthann, Markus Nielbock, Eduardo Penteado, Markus Pössel, Saeed Salimpour, Gwen Sanderson, Rebecca Sanderson, Anna Sippel

Organizing Committee:
Asmita Bhandare, Silvia Casu, Niall Deacon, Dario del Moro, Samir Dhurde, Giuliana Giobbi, Edward Gomez, Renate Hubele, Tshiamiso Makwela, Sivuyile Manxoyi, Markus Nielbock, Eduardo Penteado, Markus Pössel (Chair), Sara Ricciardi, Rosa M. Ros, Saeed Salimpour, Stefano Sandrelli, Anna Sippel, Aniket Sule, Stefania Varano, Alessandra Zanazzi

Scientific Advisory Committee:
Asmita Bhandare, Silvia Casu, Niall Deacon, Dario del Moro, Samir Dhurde, Urban Eriksson, Michael Fitzgerald, Giuliana Giobbi, Edward Gomez, Andrej Guštin, Marietta Gyulzadyan, Renate Hubele, Fraser Lewis, Carolin Liefke, Tshiamiso Makwela, Hakim Luthfi Malasan, Sivuyile Manxoyi, Surhud More, Markus Nielbock, Arvind Paranjpye, Eduardo Penteado, Markus Pössel, Carmelo Presicce, Travis Rector, Sara Ricciardi, Nayra Rodríguez Eugenio, Gustavo Rojas, Rosa M. Ros, Saeed Salimpour, Stefano Sandrelli, Anna Sippel, Aniket Sule, Rachele Toniolo, Rosa Valiante, Stefania Varano, Sarita Vig, Alessandra Zanazzi, Anita Zanella

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.

Student Competitions

Session organiser: Aniket Sule,
Homi Bhabha Centre for Science Education
(HBCSE-TIFR), India

Session overview

The session on the student competitions was focussed on discussing the role of competitions in the life of school students. School level student competitions come in different forms. Some competitions like Olympiads give importance to challenging problems and invite the brightest students to solve them in a time bound manner. Some other competitions invite students to participate in small research projects. Such projects can be in the form of building a small gadget or can be collecting data from a simple experiment or preparing a detailed plan proposal for a futuristic idea. There are also a number of outreach oriented competitions, like astronomy themed drawing / photography contests, theater performances or quizzes. These types of competitions pique student interest in Astronomy.

In order to cover this wide spectrum of competitions, the academic committee of the session chose five speakers. Greg Stachowski, who is the president of the International Olympiad on Astronomy and Astrophysics (IOAA), spoke about motivation behind the organisation of Astronomy Olympiads as well as positive outcomes of these competitions. Josina Nascimento, who has worked with the Brazilian National Astronomy Olympiad for a number of years, spoke about how a national astronomy Olympiad programme can create a large participation base across the country covering the majority of schools and support inclusive practices. Ioana Zelko, who was a student participant in multiple international Olympiads and is currently a mentor for USA Astronomy and Astrophysics Olympiad, talked about the role Olympiads play in the life of a student and how it can motivate students to take a serious look at a career in astronomy research. Danijela Takač, who - as a school teacher - has worked with the Croatian National Astronomy Olympiad for a number of years, talked about how mini research projects by school students can be part of national Olympiads and what value such open ended exercises offer to students. Lastly, Olayinka Fagbemiro, who volunteers for Astronomers Without Borders in Nigeria, spoke about an art competition for school students, which unleashed students' creativity and opened a window for adults to get a glimpse of students' ideas about space and astronomy.

Talk contributions

The Purpose of Olympiads

Speaker: Greg Stachowski, Pedagogical University of Cracow, Poland

Science olympiads are a form of intellectual competition for school students originally inspired by the sports Olympics, and just like in sports they can motivate young people and provide a framework for them to learn and grow. In this talk I will briefly explain the International Olympiad on Astronomy and Astrophysics and how it (and national level competitions) can help education by inspiring students, as a resource of educational materials for teachers and as a means to connect students and teachers with amateur and professional astronomers.

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

In this talk I would like to introduce the guiding principles behind olympiads, show how they can help with education in astronomy (and by extension in other STEM subjects) and explain how an event such as the *International Olympiad on Astronomy and Astrophysics* works.

The name "olympiad" was deliberately chosen by the founders of the first 'intellectual' olympiads in the early 20th century to evoke the spirit of the sporting Olympic Games. To quote the International Olympic Committee:

"The goal of the Olympic Movement is to contribute to building a peaceful and better world by educating youth through sport practiced without discrimination of any kind and in the Olympic Spirit, which requires mutual understanding with a spirit of friendship, solidarity and fair play."

Today the olympiads which descend from those early events aspire to the same ideals. They are competitions, but organised with the aim of motivating young people to learn and develop and do so in friendship with their peers from around the world. So how do olympiads achieve these goals? First, by channelling the natural competitiveness of young people towards learning. Rewards (progressing through different levels, receiving medals or prizes) is based primarily on personal achievement rather than 'overcoming' someone else.

Second, the syllabus and questions in olympiads go beyond the school curriculum. Students who want to participate have to learn and think independently, read more widely and practice their chosen subject. They have to develop not just problem solving skills but also learn how to seek out information and manage their time.

Third, olympiads bring together students with a shared interest from different places, across regions, across the nation or internationally.

When it comes to learning astronomy, olympiads are particularly useful because there is often very little astronomy in the school curriculum in many countries. More generally in STEM subjects,the curriculum often lags behind the latest research. Textbook problems are often theoretical or use artificial data to give the expected answer. In such cases the curated syllabus of an olympiad can be useful to students and their supporting teachers in learning astronomy. They get to solve more stimulating problems involving recent research, can perform their own observations and interpret real data, using approximation methods, iteration, error analysis and statistics - topics which are often underrepresented at school level.

Aside from this, students who participate in olympiads may be eligible for benefits such as tuition grants or university entry points, depending on their country. From the point of view of preparing a team to participate in an olympiad, training programs can easily be expanded to include more students than just the team, spreading the benefits to a wider group. Teachers also benefit from the resources which olympiads prepare. The syllabus and past papers are available and can supplement textbooks. Papers from international olympiads are translated into the languages of the participants and made freely available together with model solutions, which can be a great resource especially in countries where astronomy textbooks in the native language are not common. Several problem books have also been published in a number of languages which include a wider discussion of questions.

Finally, teachers who participate in training their students or who attend olympiads as team leaders come into contact with amateur and professional astronomers and planetarium staff, which gives further opportunities for expanding astronomy education at the school level. In turn professionals can better understand the needs of teachers and students when thinking about outreach. Participating in an olympiad can also convince students (and their parents!) that studying astronomy is a worthwhile career like, say, engineering or medicine.

Olympiads attract the attention of the media and government. This can lead to more resources and better public knowledge of astronomy. National and regional olympiads and workshops have been organised thanks to this attention and a junior International Olympiad is in the works. The physical resources from olympiads such as telescopes can also be distributed for use by schools after the event. To show how an olympiad is organized we can look at the International Olympiad on Astronomy and Astrophysics (IOAA). This has taken place since 2007 and teams from about 50 countries participate, each with 5 students and 2 adult team leaders. The host country provides all accommodation and living expenses as well as cultural events, while the teams pay for their travel. During the IOAA there are three individual rounds: theoretical, data analysis and observation. There is also a team competition, and an (optional) poster competition. Questions are vetted by the team leaders. Awards are given for achieving an objective score rather than being ‘first’. Social and cultural events take place between rounds.

The theoretical round consists of classical problems: derivations, formulae and concepts, all solvable without calculus as this is not in the curriculum in many countries. The data analysis round involves real data, including measurement errors and outliers, from which the students obtain realistic results using a variety of methods. The observation round can involve any combination of naked-eye, telescopic or simulated observations and tasks such as identifying

objects, measuring positions and sizes or timing events.

The team competition mixes students from different countries, encouraging them to work together much like a real research group. The tasks are designed so that all members can contribute and this is often where students without practice at 'exam technique' can achieve good results. Finally the poster competition gives students an opportunity to showcase their out-of-Olympiad astronomy interests through conference-style posters.

In summary, olympiads are competitions which follow the ideals of the Olympic Movement. They can provide students and teachers with an introduction to the wider field of astronomy and astronomy practitioners beyond the school curriculum, and should be thought of as another tool for our common goal of improving and propagating education in astronomy.

Building up a National / Regional Talent Nurture Program through Competition

Speaker: Josina Oliveira do Nascimento, Observatório Nacional – ON/MCTI, Brazil

Collaborators: João Batista Garcia Canalle (Instituto de Física – IF/UERJ), Eugênio Reis Neto (Observatório Nacional – ON/MCTI), Gustavo de Araújo Rojas (Universidade Federal de São Carlos), José Bezerra Pessoa Filho (Instituto de Aeronáutica e Espaço – IAE/MD), Júlio Cesar Klafke (Universidade Paulista – UNIP), Thiago Paulin Caraviello (ETAPA)

The Brazilian Astronomy and Astronautics Olympiad (Olimpíada Brasileira de Astronomia e Astronáutica; OBA) is an annual national educational competition inaugurated in 1998 and currently in its 24th edition. Its main goal is to improve science education using astronomy and astronautics as motivators. As a consequence, it increases the students' interest in these subjects. Despite not being part of the national school curricula, astronomy's appeal as a fascinating and multidisciplinary science act as a catalyst to bring students and teachers alike closer to other sciences, such as mathematics, physics, and chemistry, and other disciplines like geography, history, philosophy, and arts. One may question how a competitive event such as an Olympiad can foster the rise of new talents. Part of the answer lies in the strategies employed to attract and capacitate teachers from all school levels. We will also show how we have successfully reached teachers and students from all states in Brazil and how the wide-ranging award scheme stimulates the emergence of new talents.

Talk link: https://youtu.be/_n2CoPt5crE

The first factor that contributes to the formation of national talents is the innate objective of the olympiad, which, since its conception, has been much more than a competition, but rather a way of piquing the interest of the children and the young in science. OBA was intended to be used as a pedagogical resource, an instrument that, much more than awarding the best students, reached the objective of captivating the interest of the younger population in science. The exam should be interesting and designed in a way that aims to not draw back the student due to lack of necessary knowledge. Without a doubt, the event could serve also to reveal young talents, promote astronomy and unite people that worked in the teaching and popularization of astronomy [1].

The second factor is the reach of the olympiad since the first year of elementary school, when children are still learning to read. The exam is presented through simple phrases and images that lead the student to think about the nature in which they live.

The third point is the structure of the exams. The exams are applied at 4 different levels according to the school year, from elementary school to high school. The olympics exams themselves are moments of learning. The questions bring specific knowledge and motivate the student to develop the rationale using the other curricular course contents as base.

The fourth factor is fundamental for the success of this enormous action and consists of the capacitation and constant communication with the professors. Since 2009, OBA has promoted the EREAS (Encontro Regional de Ensino de Astronomia/Regional Meetings of Astronomy Education) aiming to capacitate elementary, middle and high school teachers in astronomy education, with 78 meetings to date. Other actions have arisen in several parts of the country having the Meetings as inspiration, with the two projects dedicated mainly to the continued formation of the teachers, but also with actions along with students. They are "Olhai pro Céu" / "Look Up at the Sky", which is a project in partnership with the (ON) (Observatório Nacional/National Observatory) and the MAST(Museu de Astronomia e Ciências Afins/Museum of Astronomy and Related Sciences) in Rio de Janeiro and "AstroEducadores" (AstroEducators), which is an online platform of national reach.

The Meetings EREAS and Look Up at the Sky are not happening during the pandemic caused by the new SARS-CoV-2 coronavirus, but the AstroEducators modules are occurring, since such project was already designed in 2013 to be a remote course, with tutoring and always with development of activities that can be reproduced in the classroom.

The following books were distributed broadly and free of charge to schools throughout Brazil: "Astronomy Guide: Continued Graduation of Teachers" [2] and "Astronomy and Astrophysics" [3]. Besides, in its homepage [4], OBA publishes an ample volume of didactic material and explanatory videos with the proposed activities for teachers to develop with their students. Using social media and digital communication tools, OBA is in constant contact with the teachers, as well as with the students.

The fifth factor is related to the broad awarding to students and the motivation for award ceremonies. In the last year of in-person exams, in 2019, the 22nd edition of OBA had 884,979 students distributed through 9,965 schools. 49,648 medals were awarded, as well as certificates for all the students, teachers and schools [5].

The sixth factor is related to the effect of vectorization, since groups of talented students, who won OBA medals, have been organizing informal groups to prepare new students to join and win their own OBA medals. Along the same lines, students who were selected to participate in Brazilian teams at the international olympiads have volunteered to prepare the next teams. Certainly, OBA has been contributing to the success of many students, seeing as many of the medalists receive scholarship offers, either partial or whole, from excellent private schools. Others, after concluding high school, were accepted by renowned international universities, such as MIT and Harvard University. More recently, some Brazilian universities are also reserving spots for the olympic medalists

References:

1. CANALLE, J.B.G. Olimpíada Brasileira de Astronomia e Astronáutica (OBA). In MATSUURA, O.T. História da Astronomia no Brasil (2013). 1st Ed. Volume II. MAST/MCTI, Cepe Editora e Secretaria de Ciência e Tecnologia de Pernambuco, Recife, 2014. Oscar T. Matsuura (Org.). p. 420-448.

2. CANALLE, J.B.G. and MATSUURA, O.T. Manual de Astronomia. Formação Continuada de Professores. Curso Astronáutica e Ciências do Espaço. AEB Escola. Ed. 2007. Sinergia. Rio de Janeiro, 2012. 188p.

3. OLIVEIRA FILHO, Kepler de Souza; SARAIVA, Maria de Fátima Oliveira. Astronomia e Astrofísica. 2. ed. São Paulo: Editora Livraria da Física, 2004.

4. CANALLE, J.B.G. Olimpíada Brasileira de Astronomia e Astronáutica, 2021. Conteúdos sobre a OBA e MOBFOG para alunos e professores http://www.oba.org.br/

5. CANALLE, J.B.G et al. XXII Olimpíada Brasileira de Astronomia e Astronáutica. OBA, 2019. Disponível em: http://www.oba.org.br/sisglob/sisglob_arquivos/Relatorio.pdf

Competitions from the Perspective of a Student

Speaker: Ioana Zelko, University of California Los Angeles, USA

Competitions create an educational opportunity for students of all backgrounds. In this talk I will discuss data that shows that by participating in competitions, students can learn to feel like scientists, get to know interesting peers from other countries, learn from each other, solve fun challenges, learn the value of teamwork, and have an overall fun and rewarding experience. Awareness of the existence of the competitions can motivate a student to start learning the subject, and good results in competitions have resulted in college admission and retention of interest in research.

Talk link: https://youtu.be/m4wIHGiSwE0

This talk will discuss four aspects of the competitions from the perspective of a student. First, I will do a brief summary of what the "process" looks like from the perspective of a student, with training and participation. Then I will discuss the impact on education, and community building. Finally, I will conclude with the contributions of competitions to research retention.

Let us start with the competition "process" as seen from the perspective of the student. The first and sometimes most important step is awareness of the subject and the existence of the competition, combined with motivation to participate. Very often, students have never heard of the astronomy or astrophysics competitions, and they may not be aware of what the field is about, or what the problems and questions in the field are like. Letting students know about the existence of the competition is a very important part of the process. The other key ingredient is motivation. Students need to be able to visualize themselves participating, and to know the benefits in doing so.

The next stage is the training. The training process varies based on opportunities available to the students, such as the existence of local teachers and clubs. However, all the materials required by astronomy and astrophysics competitions are readily available online. This gives a student the chance to successfully train, if given the time. Independent study can often be sufficient, and self-studying students have excelled in the competitions very often.

The next step in the process is participating in the competitions themselves. Often, the competitions have different levels, such as local, national, and international. After participating in a stage, the students return to training, either in preparation for the next stage (if they qualified), or for the next year's edition. This cycle allows them to chisel their skills in the subject.

Finally, in the last step, participating students graduate high school and become alumni of the program.They often form a support network for students, as well as peers during the next levels of studies, up and beyond the PhD level. In addition, they often give back to the high school

competition programs by volunteering to train younger students and help with the organisation of the program.

Perhaps the most important aspect of the high school competitions is their impact on education. This survey shows the responses of 82 student participants in the Global e-Competition on Astronomy and Astrophysics, an online high school competition that was conducted in 2020 to replace IOAA during the pandemic. The overall picture reflected in the answers was that the students had a positive experience and that the goals of GeCAA were achieved. For example, to the question "Please rate your overall experience participating in GeCAA" on a scale from 1 to 5 spanning "poor" to "great", 98% of survey participants gave a ranking greater than or equal to 3, and for the question "Please rate how strongly you feel GeCAA made a positive impact on your view of astronomy and astrophysics", 94% of respondents gave a ranking greater than or equal to 3, with 43% choosing the maximum ranking of 5. Qualitatively, the students described the GeCAA experience with phrases such as "feeling like a scientist", "solving fun challenges", "having an overall fun and rewarding experience". Aside from the theoretical experience, competitions also give students the chance to explore the observational and practical part of astronomy. Students often get the chance to engage with telescopes and learn to observe the sky with them.

A very important aspect of the competitions is that they help build community. Through the training and participation process, students often develop many friendships, many of which last into the next stages of their life, and create their support network and community in their academic journey. In students' feedback, they said they appreciated "learning from each other", and "learning the value of teamwork".

Most importantly, the competitions at the international level bring together many countries, such as IOAA who receives participants from 46 countries, and IPhO who gets 85. This helps the students become accustomed to and develop international collaborations, which are very important for many of their future careers.

Finally, competitions play a role in research retention in the long term, and serve as a pipeline for a career in research. Competitions expose students to research questions, and get them thinking about challenges they would like to pursue in science. Problems are created straight from research applications (ex: gravitational wave detection, using transit timing variations and transit duration variations to detect exo-moons).

Competitions provide networks necessary to educate students early on on the path to research, and they create a community of researchers and mentors who are available to offer support to the students. Many alumni of the astronomy and astrophysics olympiad programs have pursued studies of math, physics and astrophysics in college, and have even pursued PhDs and beyond.

In conclusion, through the training and participation program, competitions bring an important impact on education, where they increase awareness of astronomy and astrophysics, directly educate student in the field, and provide opportunities for observational practice; they contribute to community building, encouraging friendship, communication, and international collaboration; finally, they play a role in research retention, by creating a pipeline for a career in research.

Project-Based Competitions

Speaker: Danijela Takač, Croatian Astronomical Society, Croatia

This talk will address the national astronomy competitions in Croatia from a teacher/mentor/committee member point of view. In a more than 50 years tradition of competition in astronomy there have been different models of realization. There were years only with the theoretical round, only with the project round and with their combination (nowadays). It will be shown the benefits and problems we encounter when applying each model as well as the problems of objective evaluation of project-based competitions.

Talk link: https://youtu.be/J_32mIym75Q

Astronomy competitions have been organized in Croatia since 1967. From the beginning until 2008, the competitions were organized and realised by a several non-government organizations and societies (Narodna tehnika, Astronomical Astronautical Society "Zagreb", Croatian Natural Science Society (HPD), Croatian Astronomical Society (HAD)) with support of Zagreb Astronomical Observatory, local astronomical societies, schools and Ministries.After 2008 the organization was given to AZOO (Education and Teacher Training Agency) that is still responsible for it.

The Astronomy competition consists of 3 rounds: school, county and national. At the beginning of competition (usually during December and first half of January), students must send abstracts of their projects. They are reviewed, approved (or rejected) and suggestions are sent back to them. The school round is organized by the teachers in their own schools and is a way of selecting the best students that later attend the regional competition. School round is usually held in January and consists only of a written exam. Students from 5th to 12th grade compete in 8 classes. The second round is the county competition and it is organized in March within schools in each county separately. This round consists of a theoretical exam and students are obliged to bring their project report. Every project can be realized by two students from the same class. The national committee then anonymously reviews the projects (by two referees in each class). The students with the best combined exam and project results are invited to the national round in May.

The members of the national committee have designed a grading rubric for the projects. The committee members grade the clear goals and logics of the project work, motivation, grammar and spelling, detailed and clear description of the used materials, equipment and the work reproducibility. They also grade the quality of the result analysis, calculations of the errors as well as the quality of the conclusion. In the rubric there are points for naming all the references and sources of photographs used. The last grading point and one of the most difficult ones is the innovation and amount of work put into this project. The committee also writes their remarks on the project work as well as suggestions for improvement.

Upon attending the national competition students write the theoretical exam and afterwards present their project using the Powerpoint presentation. There is also a rubric to help the committee with grading the presentations and posters. This rubric evaluates the clearness and order of the presentation, how the student is familiar with the theme of his project, the presentational skills, the design of the presentation as well as the quality of the suggested improvements the students made. Final ranking list is made based on the exam, presentation/poster results and project review. The winners and runners up are invited to attend the selection for the national IOAA team, organized by the Zagreb Astronomical Observatory and Croatian Astronomical Society.

During the years we have tried different approaches to organizing astronomy competitions. When I first started teaching astronomy, 4th grade students (10-year-olds) could also compete on the regional level but only with the written exam. As a teacher I found it very motivating for the students because they could get the overview of the competition before attending it in the 5th grade. In middle school, astronomy is an extracurricular activity and teachers usually have it once a week, but it is mostly not enough if students want to participate in the competition. Teachers have to prepare students not only for the written exam but also mentor them during the making of the project. High school students are easier to mentor since they are more independent as the 5th and 6th grade students have to be mentored step-by-step. The biggest problem usually is the math background (statistics) and their minimum knowledge of the scientific method. Sometimes teachers have to be very creative when choosing the topic of the project and making it more simple for the young students. They also have to keep in mind that any project you are competing with should have measurements, calculations and analysis of the results and calculations of the errors. This is easier to do in the last two grades of middle school as the students have physics and chemistry as subjects and understand the scientific process. Nevertheless the project part of the competition is the most demanding and the most rewarding. Students have to work extra hard for a month or two depending on the topic and they learn so much more than during regular lessons. In fact, the astronomy competition is one of the most demanding STEM competitions in the Croatian educational system. For example, the national physics competition has two categories: theoretical (exam) and project-based one, but in astronomy they are combined in one.

As a teacher/mentor I usually choose the students that will attend the competition very early in the school year and start working with them on their project long before January. I usually help the youngest students decide on a topic and design a project that could be measured in the daylight or for just a few nights of stargazing since one cannot expect 10-year-old students to spend nights outside measuring in the cold.

Teachers try to motivate students by integrating astronomy projects in the physics or technology curriculum, explaining to them that by doing these projects they would "become scientists" and get an idea of the exciting work real astronomers do every day. After the students pick their project topic they explore it online, make a plan on the experimental measurements and prepare stargazing charts. After gathering the measurements students analyse them and write a report (10 - 15 pages). Before the national competition students design a Powerpoint presentation and a scientific poster. I love the idea of a poster because it gives a "real scientific conference vibe" and the students can browse the posters the committee hangs in the halls of the venue and brainstorm the ideas for topics they can do for the next year’s competition.

During the years the national committee has tried different approaches to the competition. National competition consists of only exams, but as it is only theoretical knowledge and in astronomy observing the sky is a "must" and a biggest motivation for students and future young scientists so it was not very well accepted. The committee also tried to hold the national level of the competition with students only presenting their projects but the students felt it was unfair and subjective because some national board members liked some topics more than others, so it was decided to hold both theoretical and practical parts of the competition. This is not a perfect system but for now it works well. There are some margin for errors as well as room for improvements. For example, the biggest problem we are facing is the lack of students that are willing to compete. There are many factors that contributed to that through the years, like the fact that the Ministry of Education does not allow astronomy to be a optional subject, but only an extracurricular activity which brings problems to teachers as they are often not supported for that and students do not get grades so they are sometimes not motivated in taking part of it. Also we have found that mostly physics and geography teachers feel confident enough to teach astronomy and prepare the projects for the competitions.

Anyhow, experienced teachers, with the help of astronomers, organize teacher trainings as well as workshops for young children and students in order to increase their interest in Astronomy and STEM as well as teach them scientific literacy.

Astronomy Education: Unlocking Creativity in Kids through Astro Art Competition

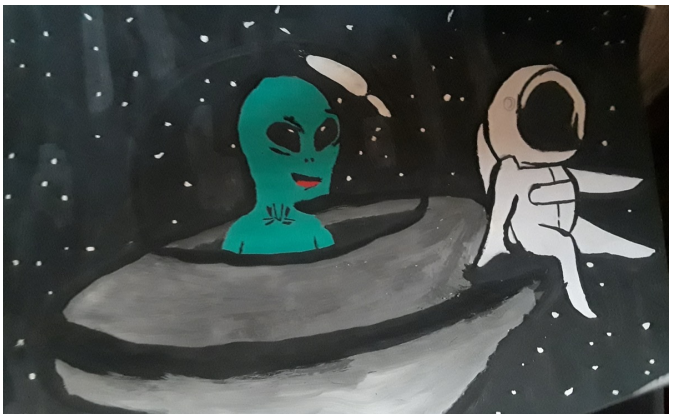
Speaker: Olayinka Fagbemiro, Astronomers Without Borders (AWB), Nigeria

An excellent medium of teaching astronomy to kids, especially from less privileged background is through Arts which provides an avenue to express their creativity. The Covid-19 pandemic which resulted in a prolonged lockdown on schools across Nigeria was utilised by AWB Nigeria to launch the first ever Astro Art Contest in the country. This maiden Edition of the Astro Art Contest for Elementary and High School kids in Nigeria saw 164 entries sent in by participants from across Nigeria. The star prize in this contest being a SSVI homemade telescope signed by foremost Belgian Astronaut, Dirk Frimout was a great motivation for participants. For entries submission, participants were expected to make paintings on an A4 sized paper accompanied with a short write up describing their art work.

Talk link: https://youtu.be/gNTh0rwq55c

An excellent medium of teaching astronomy to kids, especially from less privileged backgrounds is through Arts, which provides an avenue to express their creativity. AWB Nigeria launched the first ever Astro Art Contest in the country. This maiden Edition of the Astro Art Contest involved Elementary and High school kids aged 8 - 18 years. The participants were required to send in their entries, Astro Art paintings on an A4 sized paper accompanied with a short write up describing their artwork. In all, 164 entries were sent in by participants from across Nigeria. There are a number of lessons we got from the competition. Kids have interesting ideas about Astronomy. The participants came up with really great ideas about their understanding of Astronomy. Their paintings showed they understood the concept of Astronomy reasonably well.

Art brings out the creativity in kids. With arts, the imagination of these kids is unlocked and they begin to showcase great talents. Kids ask the most intriguing questions about space. They want to explore the many possibilities that lie within and outside of our cosmos. Creative Art presents a great avenue to teach Astronomy to kids without having to worry so much about the technicalities and big terms they may not fully understand. Having an Astronomy competition that is art-based created the opportunity to explore different aspects of Astronomy in a country where Astronomy is not taught at the Elementary and High school levels. The winners of the Astro Art competition were rewarded appropriately and there were a lot of consolation prizes as well. This was done to motivate the kids and encourage them to do better in subsequent editions of the competition which we believe has come to stay.



The Educational and Scientific Importance of the CanSat School Project

Presenter: João Dias, ESERO / Ciência Viva, Portugal

CanSat Portugal is an educational project of ESERO Portugal, organised by Ciência Viva and ESA. This initiative challenges secondary school students from all over the country to design and build a functional model of a small satellite with the same dimensions as a soda can. All teams are given a primary mission and have to choose a secondary one. They have to design and build their own CanSat, along with its parachute, prepare it for launch, assure its communications with the ground station and analyse the scientific data obtained. They are also strongly advised to look for external scientific and technological support. Overall, this competition engages the students to work together as a team on a real space mission and to live a challenging yet fun scientific and technological experience.

Poster link: https://youtu.be/rh0YmNEXm94

CanSat Portugal (https://www.esero.pt/568/8---edi--o-do-CanSat-Portugal) is an educational project of ESERO Portugal and Ciência Viva's National Agency for Scientific and Technological Culture. This competition has an international version run by ESA Education for the winners from each country.

This initiative challenges teams composed of 4 to 6 secondary school students from all over the country to design and build a functional model of a micro-satellite with the same dimensions as a soda can – hence the name CanSat. This competition gives students the opportunity to go through all the stages of a real space project throughout a whole school year. Each team's work is mentored by one teacher from their schools. The mentors do not need to be science teachers. The process required to develop a CanSat implies a learning process known as *problem-based learning*, a teaching method in which the students are the main characters and must be the ones who solve the problems. In Portugal, the students' work is evaluated in the competition's final by a jury composed of experts in Space education, science and technology. Essentially, they are all researchers and/or engineers working in space-related companies and scientific institutions.

All teams have the same mandatory primary mission to achieve, which allows the jury to compare the work developed by each team, their results and the methods they use to reach a common goal. In particular, it consists in measuring the atmospheric temperature and pressure. Each team also has to choose a secondary mission of their own, offering the students the opportunity

to make use of their creativity and knowledge to achieve an original scientific goal. In general, all teams have to design their own CanSat, integrate all its components, test its systems, build its parachute, prepare it for launch and analyse the scientific data obtained. The students are also responsible for the satellite's communications with its ground station. In other words, this school project invites the students to make good use of what they learn in the school curricula and tests their skills to work together as a team on a challenging and innovative Space project involving so many theoretical and hands-on activities with a high level of difficulty.

The students are also invited to promote their work in their educational community and on social media and are highly advised to look for external scientific and technological support, such as partnerships and consultancy. In addition to technological and scientific competences, students develop other skills such as teamwork, communication in Portuguese and English and problem solving. The winners of each edition have the opportunity to represent Portugal in the European CanSat Final, which takes place every year. Overall, this competition engages the students to work on a real and large-scale Space mission and to live a demanding yet fun scientific and technological experience.

On a final note, it is very rewarding for us, as organisers of this competition, to see the great impact it has had over the years on the student's lives, their higher education performances and even on their future careers. Just to give an example, many of them got university scholarships for participating in CanSat or were offered internships in the industry or science research centres. But most of all, it is textbfvery rewarding for the students to reach the final of such a demanding competition after a whole school year of hard work, fulfilling their dream to see the micro-satellite they built being launched from a rocket, falling down safely with the help of the parachute they built, to collect their signals with an antenna they built and to analyse the results of the mission they choose, reaching a scientific goal together as a team. I am sure they will all remember and cherish this experience for the rest of their lives!

Innovation in Space Science Learning Project

Presenter: Madelaine Rojas, National Secretariat of Science, Technology and Innovation (SENACYT), Panama

The free professional development programs and astronomical contests inspire, engage and empower the next generation of Panamenian scientists. The number of registered in all the activities presented a decrease in the pandemic. Therefore, the objective of the study is to correlate audience participation to astronomy outreach activities. For this study we have maintained an updated participants database that allows a qualitative, quantitative, and documentary analysis. The database is categorized by regions, gender and interests. Audience participation rates differ by gender with 60% female participation in astronomical competitions and 90% female participation in professional development programs.

Our intention with the Space Science Learning Project is to inspire the general public, the next generation of space enthusiasts and the educational community with tools and experiences that allow them to get an idea of what it means to be an astronomer, to work in science, and to discover the mysteries of the Universe. The project´s mission is to promote and safeguard astronomy in all its aspects, including research, communication, education and development, through international cooperation.

Throughout the pandemic, free professional development programs and astronomical contests have remained active to inspire, engage and empower the next generation of Panamanian scientists. In our country we have different activities to promote astronomy popularization and education. However, even though the number of registered participants in all the activities that we have carried out have been acceptable, we have presented a noticeable decrease in the number of people who remained participating continuously.

Therefore, the objective of the study is to correlate audience participation to astronomy outreach activities. For this study, we have maintained an updated participants database that allows a qualitative, quantitative, and documentative analysis.

The database is categorized by regions, gender and interests. Audience participation rates differ by gender with 60% female participation in astronomical competitions and 90% female participation in professional development programs. It will be presented how the analysis to develop an astronomy education kit aimed for teachers and how this cooperation between an academic institution and schools is helping educators in their pedagogical practice to teach astronomy in the classroom.

Every year, students and teachers from all over the country take part in the Panamanian Space Sciences Olympiad (OliPaCE). This has the aim of both spreading space science concepts and training teachers about these topics. A valuable link with the community at the national level will be generated by involving the entire educational sector in Panama, including children with special needs.

Also, we educate new generations of teachers and re-educate the current ones. We work with university professors and amateur astronomers in order to train future teachers and we cooperate with the departments of education in order to train experienced elementary and high school teachers.

The Innovation in Space Science Learning Project has a Network for outreach coordinator that visits a marginal community to help tackle educational disparities and improve access to STEM for women and girls in astronomy. The main goal is to set up in each country a local group of outreach members who carry on teaching space science every year and create new courses by using our materials, like animations, articles, photos, games, simulations, interactive programs and videos.

Qatar Astronomy Olympiad for Schools

Presenter: Hani Dalee, Olympiad Coordinator and IAU-NOC, Qatar

In our poster, we are going present a summary of "Qatar Astronomy Olympiad for Schools" and its different projects, which were carried out in different editions of the Olympiad. We will show the positive impact, as students were involved in the work. We will also show how we could utilize these events to create a community of amateur astronomer descending from different nationalities who are living in the State of Qatar.

Poster link: https://youtu.be/kFPgEJIkYFY

Qatar Astronomy Olympiad for Schools is an annual competition started at HBKU university in 2015-2016, in cooperation with QNRF and the Ministry of Education.

The competition is dedicated for the students in both middle and high schools. It covers topics about astronomy, astrophysics, astrophotography, space physics and other applicable topics.

So far, six Olympiads were organized with 17 astronomical projects carried out by students.

The average number of students participating in the Olympiad every year is 300 students from local and international schools. Each school was asked to form a team of 4-6 students to carry out the assigned projects, one or two teachers were allowed to supervise this team, with 60 is the average number of schools participating in the Olympiad each year.

Projects of the Olympiad: Each competition was fulfilling particular objectives, depending on the level of students targeted; middle or high school students.

1st Olympiad - 2015/2016 - 35 schools from 160 Students. The projects are: Eratosthenes Measures the Circumference of the Earth, How the Big Dipper will look like after 100,000 years from now, Hands-on for the Real Model of the Solar system and Assemble your Galilean Telescope.

2nd Olympiad – 2016/2017 - 344 students from 59 schools. The projects are: Make a Sundial for Your School and Make an Astrolabe and Use It.

3rd Olympiad - 2017/2018 - 420 students from 84 schools. The projects are: Al-Biruni measures the Radius of the Earth, Make a Star Dome and The Qatari Calendar: Study & Analysis.

4th Qatar National Astronomy Olympiad for Schools – 2018/2019 - with 340 students from

65 schools. The projects are: The Physics of the Winter Hexagon Stars, make a Model for the Stars of the Winter Hexagon and Draw the constellations of the Winter Hexagon.

5th Olympiad – 2019/2020 - 220 students from 56 schools. The projects are: Mercury Transit- 11 November 2019, Annular Solar Eclipse- 26 December 2019 and Voyager's Pale Blue Dot- 30th Anniversary 14 Feb 2020.

6th Olympiad – 2020/2021 - 246 students from 57 schools. The projects are: Measure the Distance to the Moon by Parallax and Lunar & Solar Mansions.

Benefits and output of the Olympiad: Enthusiasm among students was seen through their manner of talking and explaining. A group called Amateur Astronomy in Qatar was founded and the Qatar team for the International Olympiad on Astronomy & Astrophysics was formed.

Discussion summary

The talks were followed by a lively discussion with the speakers. Audience members were interested in knowing more details about project-based competitions that are integrated in Croatian Astronomy Olympiad program. There were queries how students found the whole experience and how much support such a concept gets from school teachers. One of the colleagues of Danijela Takač joined the discussion and explained that the teachers mentoring the Olympiad participants realise value of such proto-research projects and hence are very enthusiastic in helping their students. There were also questions about prestige associated with Astronomy Olympiads vis-a-vis Physics or Mathematics Olympiad and if Astronomy Olympiad like competitions can be introduced for slightly younger students (roughly aged 14-15). The speakers explained that the Astronomy Olympiad is much younger than Physics or Mathematics Olympiad, hence it would be unreasonable to expect similar levels of participation immediately. Speakers also discussed the need to have an ecosystem of student competitions where all competitions learn from each other and work towards the common goal of attracting school students to astronomy.

http://astro4edu.org

@astro4edu

IAU OFFICE OF ASTRONOMY FOR EDUCATION

OAE

THE SHAW PRIZE 邵逸夫獎

IAU