

Astronomy for development in Portuguese-speaking countries

The PLOAD — Portuguese Language Office of Astronomy for Development — was established in 2015 by the International Astronomical Union (IAU) with the goal of promoting astronomy as a tool for sustainable development in Portuguese-speaking countries.

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Portuguese-speaking nations — Brazil, Portugal, countries in Africa (Angola, Cape Verde, Guinea-Bissau, Mozambique, São Tomé and Príncipe — Lusophone Africa, LA, hereafter) and in Asia (East Timor) — have been historically challenged by socio-economic, political, educational, scientific and technological issues, making them key countries in which astronomy can be a tool for development. In this context, as shown in Fig. 1, the IAU's OAD (Office of Astronomy for Development) established in 2015 a language specialization and Portuguese culture centre called PLOAD. The group is primarily focused on the implementation of the IAU's [Strategic Plan](#), which seeks to take advantage of the multiple dimensions of astronomy that benefit society and can trigger development, with special regard to the [millennium development goals](#) established by the United Nations (UN) in 2000 and [updated in 2015](#), as displayed in Table 1.

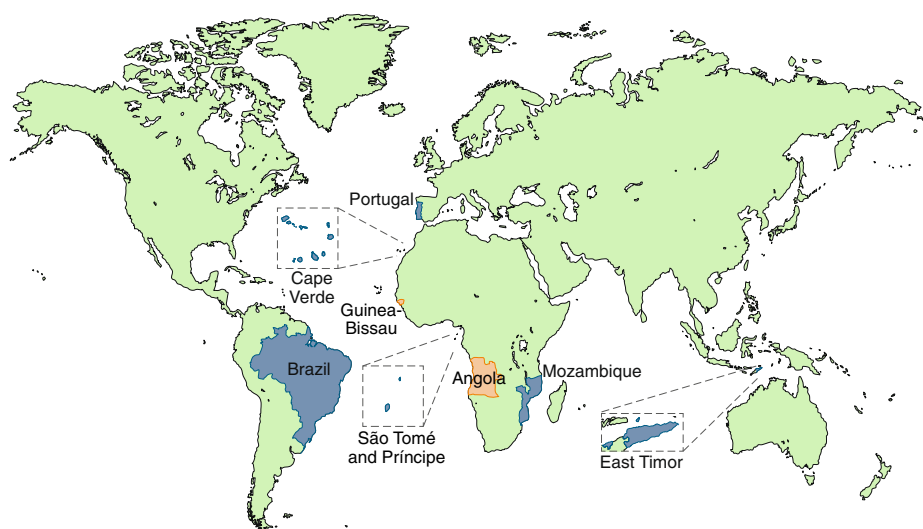


Fig. 1 | Portuguese-speaking countries. Member countries (blue) and potential/targeted partners (orange) of the PLOAD network are shown. Portuguese is the most spoken language in the Southern Hemisphere with Brazil accounting for approximately 90% of the 240 million speakers in the lusophone community.

Key challenges

The PLOAD's main challenge is to guarantee and promote the deepening of the links between its countries, which involve efforts covering four different and complex continents, through a network of individuals (researchers, professors, teachers, students, amateurs astronomers and other professionals) from different institutions (universities, museums, planetariums, science centres, schools and communities). Astronomy for Universities and Research, Astronomy for Children and Schools and Astronomy for the Public are three key task forces of PLOAD.

Brazil has a strong economy but it is socially unequal, facing several issues regarding its educational, scientific and technological programmes. Over half of the Brazilian population (54%) is made up of people of colour, who are the most disadvantaged ones in the country¹. Brazil's primary and secondary schools, which

are largely attended by people of colour, are weak. There are also large vertical inequalities in household income and the cognitive skills of 15-year-old students (see ref. ² and references therein). In terms of science, technology and their dissemination and communication, Brazil has recently faced new challenges, as summarized in ref. ³. In addition, there is a strong underrepresentation of women, people of colour and indigenous people in science and technology careers (see, for example, refs. ^{4,5}).

LA (see the African Union's Agenda 2063) and East Timor face a broad range of challenges. These include the creation of infrastructure, human resources (capacity building), equipment, as well as the development of strong curricula that introduce astronomy in undergraduate and postgraduate courses. Building planetariums, observatories and science

museums is important for motivating young people, as well as improving the scientific environment and changing the general public's perception of science. In contrast to LA countries, Mozambique already counts a few PhDs in astronomy working in the universities in the capital Maputo. Cape Verde has been defined by the IAU Strategic Plan 2010–2020 as an “underdeveloped astronomy country” that “neither adheres to the IAU nor contains individual IAU members”. However, Cape Verde is considered an emerging nation with a truly transformational development agenda and many astronomy education actions oriented to teachers and students have been carried out as part of the PLOAD partnership with the University of Cape Verde (UniCV). São Tomé and Príncipe face an even more challenging situation. Tertiary education is only available on the larger island of São Tomé. The academic level of teachers

Table 1 | UN and PLOAD goals and their relationship

UN ^a	Goals PLOAD	Related UN SDGs
A. No poverty	Encouraging effective use of the Portuguese language	C, D, I
B. Good health and well-being		
C. Quality education	Participating in the field of astronomy and space sciences	A, B, C, E, F, G, I
D. Gender equality		
E. Decent work and economic growth	Training and the exchange of researchers, teachers and students	C, D, E, G, H
F. Industry, innovation and infrastructure	Making curricula assessment and recommendations for improvements	C, E, G
G. Reduced inequalities		
H. Peace, justice and strong institutions	Establishing a solid partnership with the educational community	H, I
I. Partnerships for the goals	Promoting job opportunities among researchers, research centres and local industries by fostering internships in the institutions	A, D, E, F, G, H
	Highlighting the cultural importance of the observation of the sky	C
	Creating free access to resources to grow scientific literacy	C, D, G
	Promoting the social benefits of astronomy around the lusophony	A, B, G, H
	Providing a more inclusive environment in astronomy for women, people of colour, the LGBT+ community, and indigenous and disabled people	A, B, C, D, G, H
	Establishing a portal for the entire network	H, I

^aNote that although there are 17 UN Sustainable Development Goals (SDGs), the PLOAD team has not currently targeted all of them.

in Príncipe is a major issue, since the two islands are connected only by plane.

Key actions and results

The PLOAD team has strived to get funds from national and international agencies, but has not always been successful. Over the last three years we have been dealing with a limited budget of around US\$42,000 in total, which has been used to cover the expenses of our international meetings and the development of our main activities. People involved in the PLOAD are volunteers and are not paid for their work.

Having our challenges and goals in mind, over the last three years we have developed numerous activities that have been articulated, strengthened and practiced within the PLOAD community. For organizational purposes, we have divided our actions into five main groups.

Cooperation without borders. Given our geographical spread, it has not been easy to connect people within our collaboration to work on our common goals. We meet regularly through teleconferencing and during the last three years we have organized three international meetings in Portugal

(2016), Brazil (2017) and Cape Verde (2018). Only in the 2016's meeting was it possible to have representatives present from all different member countries. Even though the teleconferences are much cheaper, face-to-face meetings are essential for planning actions and sharing experiences.

This year's meeting will be held in São Tomé and Príncipe, in Africa. The choice is not arbitrary, since São Tomé and Príncipe, Brazil and Portugal will play a major role during the centenary of the confirmation of the theory of general relativity. The three countries were involved with the experiments that took place in 1919 during the famous total solar eclipse. PLOAD is planning many scientific and cultural events on this occasion.

Astronomy for universities, research and innovation. Education, specially higher (tertiary) education, has been a focus within the collaboration. We understand that higher education, research and innovation are essential to a stronger economy, a decrease in poverty and improving income equality as well as increasing the level of opportunities in the countries of PLOAD. While Brazil and Portugal have strong universities

and solid ongoing undergraduate and postgraduate programmes in astronomy and other scientific fields, such institutions are absent in other PLOAD countries. Thanks to the collaboration between Brazil and Cape Verde, an international campaign was organized to obtain funds for Dulcelena Cardoso Semedo, a primary education teacher, to travel to Brazil to complete her studies in astronomy. She is the first woman from Cape Verde to obtain a *lato sensu* (specialization) degree in this field. Other initiatives include academic internships between countries and meeting to promote international partnerships between institutions in the areas of astronomy and space geosciences.

Mozambique is currently the only PLOAD country to be involved in the Square Kilometre Array (SKA) project, which is a key African project. The Mozambican node has played a key role in sharing its experience and helping to create the conditions for other African PLOAD nodes to become involved in this project.

Astronomy for children and schools.

Within the PLOAD community, there is a general consensus that quality primary education is crucial to foster development. Last year PLOAD Brazil organized several primary education training actions focused on astronomy and physics, which directly impacted hundreds of teachers and thousands of students in the country. Astronomy has been discussed in an interdisciplinary way, in the context of other fields in natural and social sciences and humanities.

PLOAD Cape Verde organized the initiative Starry Nights in Cape Verde — Astronomy reaches out to West African Islands, co-funded by OAD and aimed at training teachers from the archipelago with the help of an international team of PLOAD trainers. Four islands were visited and over 350 teachers were trained (Fig. 2). This innovative project increased the competence profile of teachers by focusing on astronomy topics integrated in an inquiry-based learning approach supported by technology. Several additional training courses were organized for teachers in Portugal, Brazil and Cape Verde.

The PLOAD has used the [PLATON project](#) (Mystery Boxes, the Great Ideas of Science and the inclusion of art in the creation of interdisciplinary classes) and other scientific methodologies in teaching, through key platforms like [Stellarium](#), [SalsaJ](#) and the [Go-Lab](#), which are powerful tools for teaching students the basics of astronomy and science. São Tomé and Príncipe also joined the global [Eratosthenes Project](#).



Fig. 2 | PLOAD activities around the world. Teacher training in Cape Verde (top-left). PLOAD programmes promote cultural astronomy for people of colour (top-right) and indigenous populations in Brazil (bottom images), among other groups.

Supporting material (books, videos, presentations and lesson plans) focused on the intersection between science, technology and culture through astronomy have been developed in Portuguese to help students and their teachers. In addition, we have made significant efforts within the PLOAD to design a common curriculum that seeks to understand the already established importance of astronomy in each country. A comprehensive guide was compiled to promote science across curricula linked to other fields of learning, including relevant cultural references and the importance of the sky in language and history.

Astronomy for the public. PLOAD understands that scientific methods can be important as tools in critical decision-making. As such, PLOAD has valued spaces for informal education, learning and dissemination of science, like planetariums (in Brazil, over a million people visit planetariums every year), museums, and observatories, and has been developing several projects to restructure thinking and logical reasoning in society. PLOAD members have undertaken astronomy outreach focused on children, teenagers and adults, including seniors.

Astronomy for equality and equity. Our team has established and promoted public policies and programmes of inclusion, diversity and equity in the PLOAD community. We have organized many actions (courses, seminars and workshops) to improve social inclusion in astronomy by promoting a more balanced distribution of women as well as under-represented ethnic (indigenous), racial and other sexual/gender (LGBT+) groups, also considering intersections with societal class, which is an important factor within the PLOAD nodes. Some of our projects include bringing young girls into a university environment, courses on robotic activities focused on girls and facilitating discussions on sex and gender education in the classroom.

PLOAD Brazil's members at the Federal University of Rio Grande do Sul are dedicated to promoting 'cultural astronomy' as a tool to explore the relationship between Brazil, Portugal, Africa and Asia from an epistemological and a historical point of view, as well as to create mechanisms to deal with the underrepresentation of people of colour and indigenous people in astronomy/physics and STEM. In Brazil, two recent laws (10.639 of 2003 and 11.645 of 2008) promote the teaching of Afro-Brazilian, African and indigenous history and culture in schools.

PLOAD Brazil has proposed (and shown in practice) that astronomy can contribute to the strengthening of these laws in education and society⁶.

Figure 2 shows images of some of the activities we have developed within the PLOAD.

Final remarks

Over the last three years, our actions have impacted around ten-thousand people in four different continents. We believe that a country and its people cannot be enhanced without the development of basic science and technology. The development of astronomy in Portuguese-speaking countries indeed promotes access to new knowledge that in turn stimulates technological advances in engineering, computing and electronics. We have witnessed that astronomy can play a key role in societal development because it strengthens the human being's sense of belonging to the apparent immensity of the night sky, awakening a feeling of deep connection to the Universe and a sense of direct responsibility for the preservation of the environment and peoples' habitats. It is for this reason that astronomy occupies a prominent place among the basic sciences for global development in the 21st century and beyond. □

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