SAMPLE

Cosmic Explorers: Space Education and Outreach

Inspiring the Next Generation

Aira Astralis

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Introduction

Space education and outreach is the deliberate work of bringing space science to everyone who is not a space scientist: the schoolchild launching her first water rocket, the teacher who has never seen a launch using NASA classroom materials, the student writing code that will run on the International Space Station, the museum visitor standing under a full-scale replica of a spacecraft, and the millions who watch a landing livestream on a phone. It is the sector of the space enterprise that touches the most people, and it has quietly become one of the largest educational movements on Earth: space agencies, planetariums, universities, nonprofits, and volunteer clubs together run programs that reach tens of millions of learners a year.

Why do space programs, which are expensive and technical, invest so heavily in education? Three reasons recur in this book. Inspiration: space is one of the few subjects that reliably draws young people into science, technology, engineering, and mathematics, the pipeline every technical nation worries about. Justification: spaceflight is publicly funded in most countries, and agencies need a citizenry that understands what the money buys, from weather satellites to planetary exploration. Legacy: a space program that inspires no next generation has no future, a truth every agency has internalized.

The chapters that follow trace the idea from its origins, through the institutions that carry it, the science of how people learn, the programs that operate today, the challenges of equity and access, and the future of the field as space becomes more commercial, more international, and more visible. The recurring theme is that space education is no longer a side activity of the space program; it is one of its central products, and in terms of people reached, arguably the largest.

The Section is unique in its capabilities to innovate complete systems for space: from first principles to applications and from ideas to demonstration and usage in space. It educates scientists and engineers and inspires research to make the space domain more valuable to society. The Section has launched in 2008 the first Dutch university satellite, the triple-unit CubeSat Delfi-C3 and in 2013 its successor Delfi-n3Xt, also a triple-unit CubeSat.

The National Space Program Management Office (in Portuguese: Gabinete de Gestao do Programa Espacial Nacional, abbreviated GGPEN) is an Angolan government agency responsible for promoting the peaceful use of space and conducting technical space studies.

GGPEN was established through the Angola Presidential Decree 154/13, page

2673. The agency's mission is to conduct strategic studies aimed at establishing cooperation agreements with technical and scientific institutions in the space domain and ensuring the creation of national technological and human competencies and the transfer of technology and know-how within the scope of the National Space Program. The Angola National Space Strategy plan for 2016-2025 was approved by the presidential decree n.

GGPEN launched the AngoSat-1 in 2017, which went defunct four months after its launch. AngoSat 2, which is the replacement satellite for AngoSat 1 is currently under development and expected to be launched in 2022.

The field's central claim is simple: a space program that only talks to itself is a program wasting most of its public value. Missions are paid for collectively, and outreach is the receipt, the way the public actually receives what it bought. This book treats space education and outreach as a discipline in its own right, with a history, an institutional structure, a science of how it works, and a set of open problems, rather than as the cheerful decoration on the serious business of engineering.

A note on scope: this is not a book about space facts. It is a book about the machinery that delivers space facts to learners, the agencies, museums, camps, competitions, teachers, and volunteers who make the delivery, and the evidence about what the delivery achieves. The account wants the cosmos itself only in passing here, as the cargo the field carries.

A note on method: the field's claims are often unmeasured, and the honest literature says so plainly. Where a benefit is proven, the book says proven; where it is believed, believed; where it is merely hoped, hoped. That discipline of labeling, borrowed from the evidence-based wing of education research, is the nearest thing the field has to a professional conscience, and it will be used throughout.

The book's plan is straightforward. It opens with the field's discovery story and its working map, walks through its characteristics and its science, places it in national, economic, and cultural context, and closes with its challenges, its future, and its case for significance. Along the way it names the institutions, programs, and formats that carry the work, and it keeps a running ledger of what is known, believed, and merely hoped about the results.

These trainings have led to the incubation of ten startups by GGPEN that are contributing to the growth of space science and technology in Angola.

Chapter 01: The Discovery of Space Education and Outreach

Science outreach, also called education and public outreach (EPO or E/PO) or simply public outreach, is an umbrella term for a variety of activities by research institutes, universities, and institutions such as science museums, aimed at promoting public awareness (and understanding) of science, including trust-building, and making informal contributions to science education. While there have always been individual scientists interested in educating the public, science outreach has recently become more organized.

For example, the National Aeronautics and Space Administration (NASA) now requires all of its projects to organize suitable outreach activities. Also working to inform the public are organizations such as Communicating Astronomy to the Public and the Washington Declaration on Communicating Astronomy to the Public that organize conferences for the public on science issues and make efforts to put outreach on a more general institutional footing.

Recently, an increasing number of projects have hired designated outreach scientists (part-time or full-time) that handle public relations for their project. There are also specialized outreach providers such as the Education branch of the Space Science Institute in Boulder, Colorado and the Education and Public Outreach Group at Sonoma State University which offer to organize a project's outreach activities on a contractual basis.

In addition to outreach by research institutions, an important part of informal science education are outreach programs such as science museums and science festivals. Science outreach can take on a variety of forms. Lectures are probably the oldest form of science outreach, dating back to the 1820s when Michael Faraday organized the first of the Royal Institution's Christmas Lectures.

Public talks can be part of a lecture series, given at a science festival or in cooperation with a special interest group such as a local astronomy club. Public presentations can have a variety of formats, including straightforward lecture formats with or without experimental demonstrations, guided live interviews, and discussions with several participants and a moderator.

One organization that focuses on this kind of science outreach is Robogals. Many universities also have science outreach programs that are dedicated to building relationships between high school students, university scientists, and K-12 teachers. A few of the most prominent university science outreach programs include Carolina Science Outreach, the Vanderbilt Student

Volunteers for Science, the Rockefeller University Science Outreach Program, the Present Your Ph.D.

Using Canada as an example, it has been estimated that with sufficient organization, every classroom from kindergarten through graduation could in practice receive a visit from one or more scientists annually with participation from only 10-15% of the scientific enterprise. Some examples of science outreach programs in Canada include: Let's Talk Science, Actua, The Chemical Institute of Canada, and Science Rendezvous.

Inviting groups of school students to a research institution for a workshop is another popular form of outreach.

Formats range from a one-day visit to more involved week-long events such as Perimeter Institute's International Summer School for Young Physicists, a two-week-long program for a total of a hundred Canadian and international students from grade 11. Another method of science outreach invites school teachers to participate in workshops where they are able to learn effective strategies to engage students in science.

This approach was especially embraced by the Canadian Space Agency (CSA) which held an annual "Space Educators" conference up until 2012 to provides teachers with access to resources to educate their students in space-related science. Besides organizing independent events, many outreach organizations sponsor existing events that promote sciences awareness. A notable examples are science fairs, public science events in which working scientists can participate both as judges and as sponsors of student projects.

For example, research laboratories often maintain educational outreach projects aimed at translating their science into something meaningful for the general public, often K-12 students, as an effort to increase research broader impacts required by funding agencies such as the National Science Foundation (NSF). These may include activities using fast-growing plants that exhibit distinctive mutants with unique phenotypes useful to teach K-12 students about both Mendelian and molecular genetics.

Some institutions and organizations maintain large or small aggregations of their activity resources, outreach programs, upcoming events calendars, and partnering programs. A number of awards honor commitment to science outreach.

To honor this achievement and promote scientific awareness, the Government of India declared 28 February as National Science Day in 1986. The day highlights the importance of science and encourages scientific thinking among students and citizens. The occasion of National Science Day is marked by

numerous events conducted by institutions such as schools and colleges. India Space Week is celebrated in India every year on 12 to 18 August.

The celebration also includes public speeches, radio, TV, Space science movies, Space science exhibitions based on themes and concepts, debates, quiz competitions, lectures, science model exhibitions and many more activities. India Space Week consists of space education and outreach events held by space agencies, aerospace companies, schools, colleges, universities, NGOs, planetariums, museums, and astronomy clubs around the nation in a common timeframe.

India Space Week is coordinated by the India Nation with the support of the India Space Week Association (ISWA).

The ISWA leads a global team of National Coordinators, who promote the celebration of India Space Week within their own countries. The ISA AND IICT declared in 2022 that India Space Week will be held each year on the

Celebration of birth of 12-18 August Vikram Sarabhai. National Science Day is celebrated to spread a message about the importance of science used in the daily life of the people.

The theme of the year 2008 was 'Understanding the Planet Earth' and of the year 2009 'Expanding Horizons of Science'. On 28 February 2009, five institutions in India were presented the 'National Award for Science Communication' by the Indian Department of Science and Technology (IDST). These awards are presented to recognize the efforts of individuals and government and non-government bodies for the popularization of science in India.

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Space education as a public enterprise began with shock. When Sputnik reached orbit in October 1957, the American response was not only rockets but schools: the National Defense Education Act of 1958 put federal money into science and mathematics education at every level, and the space race became an education race. The Soviet Union made the same calculation in reverse, celebrating Gagarin's 1961 flight with parades and school programs that made the cosmonaut the model citizen of the age. Within a decade, planetariums were spreading through school systems, and the term "space age" had entered the curriculum itself.

The Apollo years established the field's first institutions. Agency speaker bureaus sent engineers to classrooms; mission press kits became teaching materials; and the 1969 Moon landing, watched by the largest audience in history, became the founding demonstration that a space event could be a global teachable moment. The 1970s and 1980s professionalized the practice:

education offices appeared inside NASA and its international counterparts, science centers boomed with space exhibits as anchor attractions, and the Space Camp model opened in Huntsville in 1982, inviting children to spend a week training like astronauts. The Challenger accident in 1986 was the field's defining tragedy, and also the origin of one of its most effective institutions: the families of the crew, including teacher Christa McAuliffe's, founded the Challenger Center, which built space-science learning centers in classrooms' reach across the country, so that the mission that ended in seventy-three seconds continues today in millions of student missions flown in its simulators.

The international spread followed the same logic everywhere it arrived. When China opened its crewed program, it paired it with live classroom broadcasts; when India's space program matured, ISRO opened its launches to school visits and put satellite engineering scholarships at the center of its public story; when the space station era began, fifteen nations found themselves co-owners of the most conspicuous teaching tool ever built. By the 2000s, the field had its own calendar, World Space Week every October, and its own professional identity: space educators were no longer volunteers borrowing content from the space program but a discipline with conferences, journals, and career paths.

The discovery of the field is usually dated from the moment spaceflight became television. The first satellites were explained to the public mostly by newspapers; the first crewed flights arrived in living rooms. From the earliest orbital missions, agencies learned that the public did not merely want to know what was launched, but to see it, hear the crew, and share the event, and every outreach tool since has been a variation on that discovery: space is a spectator subject, and education follows the spectacle.

The teacher-in-space idea belongs to the discovery story. When a schoolteacher was selected to fly and teach lessons from orbit, the point was explicit: the classroom was being invited onto the crew. The loss of that mission in 1986 became the field's founding tragedy, and the decision, made in its aftermath, to build a permanent network of learning centers rather than rest on a single flight's symbolism is one of the clearest examples the field has of grief turned into structure.

The International Space Station brought the discovery full circle by making

school contact routine. Crew members speak with classrooms by amateur radio, student-operated cameras photograph chosen sites on Earth for classroom study, and student experiments ride to orbit on every resupply cycle. The station functions, among its other roles, as the largest continuously staffed education facility in space.

A quieter strand of discovery came from the archives. The decision to publish mission imagery freely and immediately, which the agencies did decades before the open-data movement had a name, turned every mission into a teaching library. A teacher today can build a lesson from raw spacecraft photos without asking anyone's permission, and that single policy choice has probably delivered more classroom space content than any curriculum program ever budgeted.

The internet completed the discovery. When launch video became a stream rather than a broadcast, and mission data a download rather than a press packet, the field's cost of delivery collapsed. The modern era of outreach is the story of what a field does when its raw material becomes free to move, and most of this book's later chapters are about the consequences.

One more origin earns a place in the discovery record: the amateur. Amateur astronomy clubs were teaching the public about space long before any agency had an education office, and the field's volunteer layer descends directly from them. The professionals who later built the institutions did not replace the amateurs; they industrialized an activity the amateurs had already proven, which is why the club and the star party still sit at the field's heart.

The museum strand completes the discovery. Spacecraft halls, from the earliest collections of capsule hardware to the modern walkthrough exhibits, gave the field its physical classrooms, and the museum field trip became the delivery format the public recognized before it recognized any other. To walk a school group past flown hardware is still the field's most reliable demonstration, and the discovery era's lesson holds: the artifact teaches first, and the label explains.

The planetarium's role in the discovery is easy to underrate because it is so old. The projected sky solved the field's first logistical problem, how to teach a subject whose laboratory is the sky when the sky is cloudy, and it did so a century ago. Every outreach format invented since lives in the planetarium's shadow, working the same trade: bringing the sky indoors so the learner can be scheduled.

The discovery record should end with its pattern, because the pattern is the lesson. Every era of the field begins the same way, a new medium or mission

arrives, the public gathers, and the field invents the institution that keeps the gathering after the novelty fades. The radio talk became the club; the broadcast became the museum; the stream became the program. The discovery of space education is, reduced to one line, the repeated discovery that attention is renewable if someone builds the roof over it.

The museum track of the story gets its own paragraph, because museums turned space hardware into civic identity. The great collecting institutions, the Smithsonian's Milestones of Flight hall in Washington, the Science Museum's spacecraft gallery in London, the Tsiolkovsky and Korolev museums in Russia, hold returned capsules, spacesuits, and rocket engines where any visitor can stand beside them, and their attendance figures have made the argument for public funding of spaceflight more eloquently than any agency report. Around them grew the science-center movement, which added one decisive idea to display: the hands-on exhibit, the push-button, the simulation, the climb-in cockpit, that turned the museum from a shrine into a classroom.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.