Promoting global education, teaching, and research in space science

Over just a few decades, space science and technology has become one of the most exciting and rapidly evolving fields of modern research. One crucial contributing factor to this growth has been the Regional Centres for Space Science and Technology Education project: an initiative by the United Nations (UN) to integrate regional cultures with robust educational curricula. Hans Haubold (UN's Office for Outer Space Affairs), together with A M Mathai (Centre for Mathematical and Statistical Sciences, CMSS), and Lewis Pyenson (Western Michigan University), has authored three publications that explain how the project is actively building an expert community of space scientists spanning the entire globe.

Science and mathematics are often seen as an expression of the true nature of the world around us. Yet as researchers seek to understand and control nature by studying these fields, their efforts will inevitably be intertwined with the widely varying cultures of human society: a theme that has played out throughout the entire history of scientific discovery.

Ever since ancient times, higher learning institutions have encouraged researchers to gain a theoretical understanding of nature and to apply their findings to new lines of research as well as novel technological advances. In the 17th century, newly established academies began to promote the importance of experimental science and encouraged researchers to share new ideas and results.

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Eventually, this movement gave rise to large-scale education programmes in the 19th century. This created new opportunities for expanding areas of applied science and mathematics: including astronomy, physics, chemistry, and biology. Alongside this expansion, new institutions were created, which were dedicated to specific fields of applied research. Among these was the A M Mathai Centre for Mathematical and Statistical Sciences (CMSS), established in Kerala, India, in 1964.

The CMSS was designed to encourage academic dialogue and discovery, by bringing together the latest ideas in mathematics and statistics and exploring their applications in scientific disciplines. It was established with the mission to provide high-quality education and to initiate research spanning multiple scientific fields in order to maximise their potential for benefitting society as a whole.

ESTABLISHING REGIONAL CENTRES

Owing to the exciting opportunities they present, space sciences and their technological applications have become some of the fastest-growing fields in the global landscape of modern research. Based on the earlier success of institutions like the CMSS, the UN has now mandated the promotion of new international cooperation between member states to expand the global capacity for research into space science and technology even further.

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Educators at the Regional Centres provide students access to curricula tailored to their local cultures.

For this purpose, the UN supported the establishment of Regional Centres for Space Science and Technology Education (RCSSTE) in 1988. Today, the programme has a truly global presence – with centres in India and China to serve the Asia Pacific region; in Nigeria and Morocco for Africa; in Mexico and Brazil for Latin America and the Caribbean; and in Jordan for Western Asia. In the coming years, Russia has expressed interest in establishing a new centre to serve all Russian-speaking countries.

Based on the founding principles of the CMSS, all Regional Centres in the RCSSTE are encouraged to cooperate with universities, research institutes, and enterprises in the nations they serve and to share their resources with other Regional Centres. In this way, the UN aims to strengthen the capabilities of each individual Regional Centre.

CURRICULA IN SPACE SCIENCE

Alongside these goals, each of the Regional Centres offers a detailed, university-level education curriculum for students, covering a wide variety of fields in space science. Among the topics covered are remote sensing, which can be used to acquire detailed information about the Earth's surface using satellite observations, as well as satellite communications, through which important information can be accurately transmitted across vast distances.

In addition, the curricula cover meteorology and climate science, which again use satellite observations to study Earth's atmosphere and understand its transformation due to human activity. Beyond the boundaries of the atmosphere, the centres also educate students about space weather: caused when energetic particles originating from the sun interact with Earth's magnetic field. Finally, the curricula focus on global navigation satellite systems, which allow vehicles and electrical devices to precisely calculate their speeds and positions in real time, making them a vital element of many of the technologies we now depend on.

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ENHANCING EXISTING CURRICULA

In order for each of the Regional Centres to succeed, it is crucial for educators to respect local cultures and understand how they are expressed in society. Over the past 30 years, those involved in the RCSSTE project have gained the expertise required to intertwine this cultural knowledge with space science and technology and its applications. This has provided students access to curricula that are uniquely tailored to their local cultures – an advantage that isn't widely offered by most other research institutions.

Elsewhere, educators have been encouraged to further develop existing curricula by integrating new insights into science and technology and their applications. To supplement these courses, German publisher De Gruyter has published two open access books, both freely available online:

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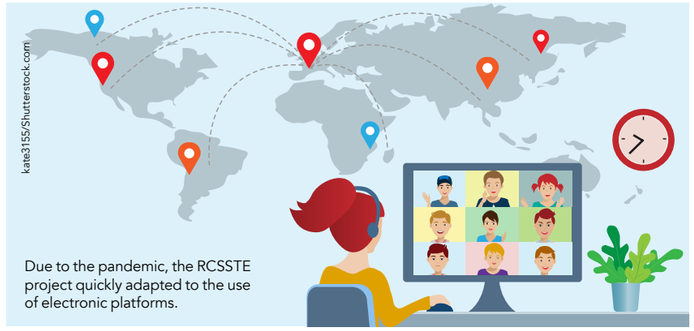


Due to the pandemic, the RCSSTE project quickly adapted to the use of electronic platforms.

one on linear algebra and the other on probability and statistics.

Both of these books have been designed for physicists and engineers; they form the mathematical and statistical foundations of the courses within the Regional Centres' curricula. Since all these education materials are available free of charge, they are now widely being implemented for education, teaching, and research in space science and technology at universities and research centres around the world.

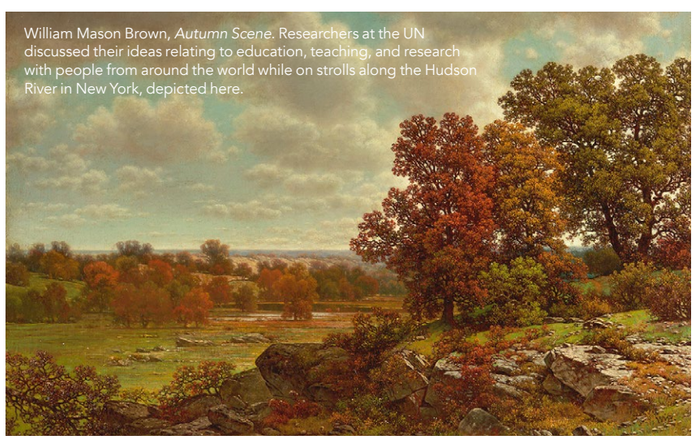
FREEDOM FROM CONSTRAINTS

For students studying at the RCSSTE's Regional Centres, the curricula they receive will have a number of key advantages. One of these is freedom from the disciplinary barriers that are present in many prestigious universities. Whereas the curricula in these institutions are often restricted by strict regulations that are notoriously difficult to change, the Regional Centres can take full advantage of the scientific ideas generated in labs and research institutions – and may even take in ideas from human sciences, including philosophy, art, and history.

A further advantage is that the educational programmes are not constrained by long-established distinctions between the practical applications of science and far more abstract theoretical ideas. For space scientists, this allows ideas and methods to be freely adopted from the latest advances in engineering. Again, this freedom has been far more difficult to implement at larger research institutions, where the engineering and science departments are often separate.

A third advantage of the RCSSTE's curricula is that they can move between the language most often used in scientific literature – named 'International English' – and the everyday languages used by students. This opens up opportunities for students to contribute new concepts based on their daily experiences and make their own original interpretations of scientific knowledge that may have stood unchanged for decades. Such multilingual advantages have already been seen in the fresh perspectives of scientists who have emigrated to the West.

Students across a far more diverse range of cultures and regions are now actively gaining the expertise needed to contribute to space science.



William Mason Brown, *Autumn Scene*. Researchers at the UN discussed their ideas relating to education, teaching, and research with people from around the world while on strolls along the Hudson River in New York, depicted here.

ADAPTING TO THE PANDEMIC

One final advantage of the Regional Centres is that their structure is well suited to a world where the COVID-19 pandemic continues to transform the landscape of scientific research. While social-distancing rules have been enforced across the globe, severely disrupting the traditional education methods used by many institutions, the RCSSTE project has quickly adapted to the use of electronic conferencing in education via platforms such as Zoom.

This new flexibility of the Regional Centres has allowed them to embrace the latest advances in e-learning, in turn allowing for curricula that promote education in many different languages. In line with the earlier founding principles of the CMSS, these advantages are now actively helping to establish a robust community of scientific researchers around the world.

Traditionally, robust educational programmes in space science and technology have been limited to established research institutions. Yet through the UN's Regional Centres project, students across a far more diverse range of cultures and regions are now actively gaining the expertise needed to contribute to the rapidly evolving field. Ultimately, the approach represents a new step forward in the long history of our efforts to develop and share new scientific concepts and applications while ensuring that new ideas are ingrained in the cultures that define human society.

Behind the Research

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W: wmich.edu/history/directory/pyenson **W:** www.unoosa.org/oosa/en/ourwork/psa/regional-centres/index.html

Research Objectives

The Regional Centres for Space Science and Technology Education, affiliated to the United Nations, provide high-quality education and form a global community of space scientists.

Detail

Bio

Hans J Haubold is Professor of Theoretical Astrophysics at the UN Office for Outer Space Affairs, Vienna International Centre, Austria. Together with Professor Mathai, he has fostered ground-breaking interdisciplinary research on astrophysics, fractional calculus, statistical distribution theory, geometric probability, and discrete mathematics, with present real-world and possible future space exploration applications.

A M Mathai is Emeritus Professor of Mathematics & Statistics, McGill University, and Director of the A M Mathai Centre for Mathematical and Statistical Sciences (CMSS) in Kerala, India. Established in 1977 as a non-profit scientific society, CMSS is now an international centre of excellence and research centre for Banaras Hindu University, Anna University, and Mahatma Gandhi University in India.

Lewis Pyenson is Professor Emeritus in the Department of History of Western Michigan University. He has authored and co-authored many books, his recent publication being *The Shock of Recognition: Motifs of Modern Art and Science* (Leiden: Brill, 2021). Dr Pyenson is a Corresponding Member of the International Academy of the History of Science and a Fellow of the Royal Society of Canada.

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United Nations

Personal Response

What steps must be taken to ensure that educators have expert knowledge in both space science and the cultural requirements of students?

"Knowledge (science and technology) and culture are very important issues; in my opinion, culture is even more important than knowledge. Teaching culturally and ethnically diverse students in the various space science and technology courses requires that educators not only acknowledge but also utilise the cultural capital that students bring to the classroom. Their cultural knowledge, frames of reference, linguistic styles, interests, performance styles, and prior knowledge are assets that make science learning more effective and relevant for them. Educators with expert knowledge can adjust their approaches to teaching by making classroom learning environments more collaborative, offering student choices, and inviting different ways of communicating, sharing, and listening into their science and technology classrooms."