SMALL SCIENCE, BIG IMPACT

JAYASHREE RAMADAS, DIRECTOR OF THE HOMI BHABHA CENTRE FOR SCIENCE EDUCATION IN MUMBAI, INDIA, WAS THE RECIPIENT OF A 2011 TWAS REGIONAL PRIZE FOR HER PIONEERING WORK IN SCIENCE EDUCATION, AND ESPECIALLY FOR HER SERIES OF TEXT BOOKS, 'SMALL SCIENCE', DESIGNED FOR PRIMARY-AGE SCHOOL CHILDREN.

Jayashree Ramadas, winner of the 2011 TWAS-ROCASA Regional Prize for the development of scientific educational material, has authored and co-authored a series of innovative text books for primary schools. 'Small Science' covers the whole of the primary school science curriculum from class 1 (ages 5 to 6) to class 5 (ages 9 to 10). The curriculum is being carried forward into the middle school by one of the 'Small Science' authors at the Homi Bhabha Centre for Science Education (HBCSE) in Mumbai, India, where Ramadas is now director.

Ramadas estimates that so far the curriculum has reached over ten thousand students throughout India. Users of the books range from elite urban schools to schools for tribal communities and migrant workers, and from conventional mainstream to progressive alternative schools around the country. Their success can be gauged by the fact that the Indian National Curriculum Framework 2005 gave prominent place to the ideas suggested by the 'Small Science' curriculum, and that other Indian states have adapted and incorporated portions of the books into their own textbooks.

Coordinator of TWAS-ROCASA and member of the TWAS Regional Prize selection committee, V. Krishnan (TWAS Fellow 1996), reported that the committee "was particularly impressed with Ramadas' long-term commitment to science education, and the real impact her work has made on improving the ability of small children to understand fundamental concepts in science. The text books she has authored are especially relevant to the Indian context, with real-world examples the children can relate to."

The 'Small Science' books build on the solid foundations of research undertaken for over 36 years by

TWAS REGIONAL PRIZES

TWAS's Regional Offices play a key role in nominating and selecting candidates for TWAS's wide variety of activities, including prizes. They also administer a number of programmes themselves. One of these is the TWAS Regional Prize. Since 2007, each of the Academy's five Regional Offices (in Brazil, China, Egypt, India and Kenya) has awarded one prize each year, worth USD3,000. The prizes rotate among the following three areas:

(i) the popularization of science

(ii) the development of scientific educational material, and

(iii) building scientific institutions.

The prizes came about as a suggestion to the TWAS Council to highlight and honour the work of people in these important areas of building scientific capacity.

The selection process for these awards involves an open call for nominations, review by an expert committee composed mostly of TWAS Fellows, and then a second review of shortlisted candidates' achievements by all TWAS Fellows in the region.The prize winners are awarded their certificates and cheques at TWAS regional meetings or other major regional scientific events.

Ramadas on science education in general, and on the collective research and field studies on the science curriculum undertaken by her colleagues at the HBCSE. The centre is well known and esteemed in India, and indeed, though she became director of the centre only last year, Ramadas began her career in science education as a PhD student at HBCSE, evaluating the impact that changes in the science curriculum had on standards of teaching in the area.

The 'Small Science' books are the result of these many years of rigorous research and pilot studies, and are based on a philosophy of child-centred inquiry, aimed at encouraging and responding to the kinds of questions and curiosities children naturally have about the world around them.

"But," says Ramadas, "children can ask questions in a very naive way. The tools we give them are derived from the processes of science observation, tabulation, argumentation and analysis. The children are encouraged to draw connections. So we begin with concrete experiences and observations and then give them ways of enriching their experiences and finding patterns in these experiences." These tools, in fact, are the basis of a sound 'scientific method' and are far more useful to them in becoming scientists, Ramadas contends, than the rote answers to rehearsed questions common to many kinds of educational text books.

The topics covered begin with everyday experiences and immediate surroundings in the earlier years, moving gradually outwards: classes 1 and 2 focus on environmental studies; classes 3 to 5 are primarily concerned with science in general, though keeping in view social and cultural perspectives; while classes 4 and 5 make increasing use of measurement concepts.

Ramadas also co-authored the 'Teacher's Book' for classes 1 and 2 and explained why no text or workbooks were provided: "The cognitive skills of young children at this age (5-6 and 7-8 years old) are in advance of their literacy skills. If you limit them to understanding text books and workbooks you are in essence 'dumbing down' their skills and abilities. Much of the work we do in the classroom at this level is based on speaking and drawing, so they can express themselves and explore their thoughts and ideas without being restricted by reading and writing skills." The 'Teacher's Book' is a compilation of activities, games and ideas grouped around different themes directly relevant to the world the children have experience of (including 'my family', 'my body', 'plants and animals', 'food', 'people and places', 'time', 'things around us'). The aim of the unit on 'my body', for example, is "to get to know one's body while learning names of the parts of the body."

The cognitive skills of young children are in advance of their literacy skills.

The suggested questions and activities are:

- How many different actions can you do with your body while remaining in one place? Do them.
- Show how many different actions you can do with your body if you are allowed to move from one place to another.

Children go on to clap, to repeat rhythms and to learn songs, to create stick figures with pencils and attach labels to different parts of the figure. They discuss how to keep neat and clean, and they are asked questions about how they grow:

- Do your clothes fit you now? What do you do with your old clothes? Bring to class some of your old clothes which are now too small for you.
- Are there things you can do or any places you can reach, which you could not do when you were younger?

Drawings are central to all the books, and Ramadas explains that the content of the books evolved together with the specific artist she was working with at the

2011 TWAS REGIONAL PRIZE FOR THE 'DEVELOPMENT OF SCIENTIFIC EDUCATIONAL MATERIAL'

The 2011 prize was given in recognition of significant and innovative contributions to scientific educational material, especially the development of "creative programmes aimed at stimulating science education in school children" that have helped to advance the quality of science education in the region.

The 2011 winners were:

- *TWAS-ROESEAP (Regional Office for East and South-East Asia and the Pacific):*
  Liu Changming, China. *Liu has served as a national education inspector for the Ministry of Education, and as a coach at the Physics Olympiad School, in the Xicheng district of Beijing. Many of the students he has taught have won gold medals in international Physics Olympiad competitions.*
- *TWAS-ARO (Arab Regional Office):*
  Nadia Al Wardy, Sultanate of Oman. *Al Wardy was instrumental in setting up a medical education unit at the College of Medicine and Health Sciences, at Sultan Qaboos University, putting the College on a par with international and regional medical schools.*
- *TWAS-ROSSA (Regional Office for Sub-Saharan Africa):*
  Peet van Schalkwyk, South Africa*. Van Schalkwyk helped to establish the first science centre in South Africa at the University of Pretoria, and the Science Garden at North-West University, both of which have served as models for later science centres in South Africa.*
- *TWAS-ROLAC (Regional Office for Latin America and the Caribbean):*
  Patricio Felmer, Chile*. Felmer has made significant contributions to the formative training of school mathematics teachers and has been the director of a government initiative to define national standards in mathematics teaching.*
- *TWAS-ROCASA (Regional Office for Central and South Asia):*
  Jayashree Ramadas, India*. Ramadas has developed a series of innovative science text books for primary school children in India.*

time. "The designer of the class 1 book was a student. She developed it as a project, then she moved on. Then I was contacted by another designer, who was a teacher-educator who loved the books, and she, in turn, had a big influence on the design and content of the next books. So, in some ways, the books are developed in tandem with whichever artist I'm working with."

Ramadas clearly has a non-competitive temperament, speaking with delight of another researcher who contacted her, developed the class 5 books and is now preparing the series of books for middle schools. Ramadas is grateful and enthusiastic: "I have other projects to be getting on with, and the books have evolved with the right people at the right time." This is in line with her philosophy that teachers and authors are not, in fact, authorities. In other words, they should not dictate or instruct in a pre-conceived way. Rather, they, like their students, need to be responsive. For this reason, the 'Teacher's Book' is not an instruction manual, but a reader-friendly guide to possible approaches, including tips and suggestions, and full of personal accounts written by other teachers who tested out the materials. "Teachers are in a learning process themselves", stresses Ramadas.

A VIEW FROM THE CLASSROOM

'Teach for India' is a nationwide movement which recruits outstanding college graduates and young professionals to teach full time in low income schools for two years, with the aim that they will go on to advocate edcuational equality in their subsequent careers. Gunvant Jain, a 2010 'Teach For India' Fellow, used the 'Small Science' textbooks at the Shantabai Ladkat English Medium School, in Pune, India.

My classroom experience started with a conversation in Jayashree Ramadas's office when she encouraged me to try the 'Small Science' curriculum in my classroom. Thoroughly convinced, I managed to raise funds to provide the books for each of the 65 children in my grade 4 classroom.

The children just loved the books so much that for the first few weeks throughout the school these books were in their hands, irrespective of whatever was being taught. The pictures, experiments and activities just touched them.

During the year, the kids never felt that it was a 'subject', they in fact loved doing these activities and experiments at home. The curriculum empowered them to feel that every observation or curiosity has an answer and it is perfectly fine to have questions and ask them.

The children began to ask questions that ranged from the process of evolution to black holes to simple water falling in a bucket at different rates making different shapes of liquid inside it. Moreover, having workbooks allowed them to write their views and observations; suddenly there was nothing wrong or right – it was just their observations that mattered. This made them feel that it is acceptable to be wrong and make mistakes because you learn from them.

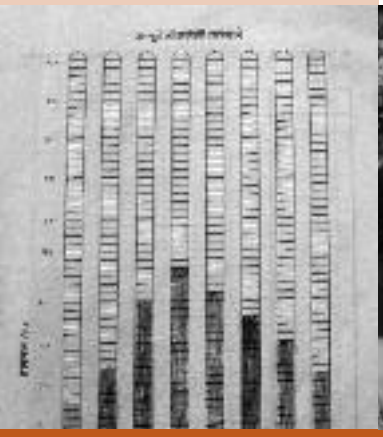
This year witnessed remarkable growth in every single child, in many aspects – including confidence, experimentation capabilities, observational skills, scientific temper, self reliance and cooperation, team building, sharing, criticizing, and a few of the children have even shown signs of hypothesizing.

This is an edited version of the description to be found on the 'View from the Classroom' pages of the 'Small Science' website at: http://tinyurl.com/bslsrht.

Classes 3 and 4 each have a teacher's book, text book and work book, and Ramadas is the sole author of them all. At this stage, language and expression take on increasing importance as key components in developing scientific skills and accurately communicating scientific observations and results: "Language is a tool that will help the students to conceptualize, to understand, and to express their thoughts. Throughout the curriculum, students apply their verbal and quantitative skills for more effective observations and inference. They also learn to communicate science knowledge."

There is attention to the sound and meaning of words, and to the development of narratives. Stories and poems figure in each chapter: "It bubbles, it blows / It creeps and it flows / It whistles, it sings / Lifts birds on their wings."

In the Indian context, this curricular approach aims to combine the strengths of the non-literate tradition (consisting of rich observations of the natural world),



and the literate culture (which contributes systematic analysis and articulation.) Students are encouraged to recount their experiences, ask questions and to engage in critical thinking, and to argue and debate. Students might be asked, for example, to both talk and write about the air they breathe every day.

"Is it clean or dirty? Why do you think so? What things make your air either dirty or clean? What can you do to get clean air?"

The curriculum is being produced in English, Hindi, Urdu and Marathi (Marathi is the official language of Maharashtra and is the 14th most-spoken language in the world). The content of the chapters, too, makes ample references to Indian reality. "In India, the monsoon season makes a big difference – everything changes after the rains", explains Ramadas. "After just one week of rain there is a large increase in the number of living things. So in the chapter on 'living things' we ask the students to observe and think about this phenomenon."

Students are encouraged to ask questions and engage in critical thinking, to argue and debate.

Summer and rains

- Choose a small patch of land near your home or school. Count how many different kinds of plants and animals you see there during the summer season. How many of these plants are trees?
- Look again after the rainy season has started. The old plants now look greener. But you also see many more, and many different kinds of small, baby plants. As the days go by they grow bigger.

You also see new animals. Look for frogs, earthworms, and different kinds of insects, like caterpillars, butterflies, beetles and flies.

Count how many different kinds of plants and animals you see in the rainy season.

Think! Think!

Where did all these new plants and animals come from? Where were they hiding in the summer?

Remember this…

We see many different kinds of living things around us. All these living things are either plants or animals. Plants stay fixed on the ground; animals move around. When it rains, we see new plants, and new animals.

Drawing and design are still seen as key to the later stages of the curriculum, as Ramadas explains in the 'Teacher's Book':

"For too many years, design and engineering have been a weak point in Indian education. Students must start to use skills of drawing and constructing spontaneously in learning concepts. They should develop an attitude of 'let's do it and see!' Learning comes out of a willingness to experiment, visual-spatial ability to design a situation, and manual dexterity to carry out

one's plans. The curriculum offers many opportunities for students to construct with their hands, to put down their observations in drawing, and to develop simple concepts of design."

Another feature of the 'Small Science' curriculum is that students are not assessed on the knowledge they have gained, but rather on the basic skills they have acquired, their ability to "learn how to learn". These skills include: observation; design, drawing and construction skills; measurement and quantitative thinking; and language development through science.

Ramadas also places great importance on a sensitivity to gender, culture and class. "Gender is a big issue – there is a lot of gender bias in educational text books. Boys are always shown in active roles, and the girl is usually watching."

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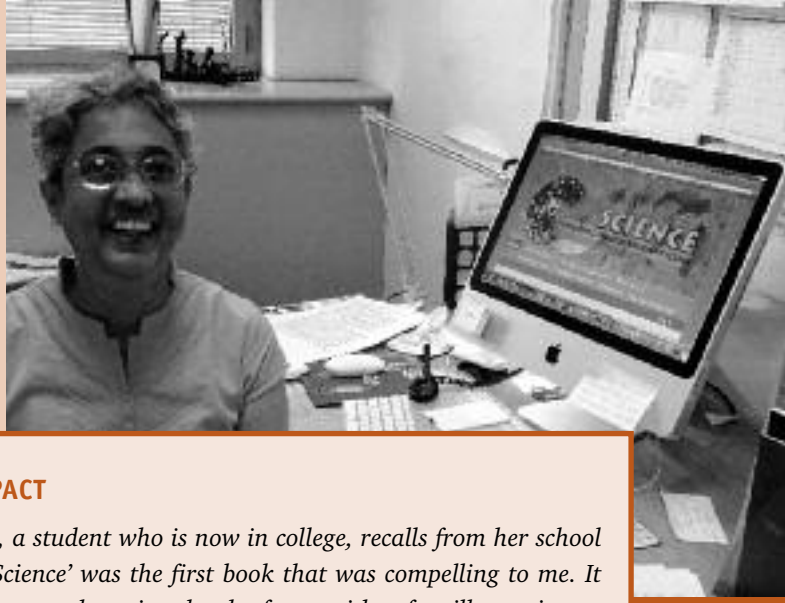
For this reason, many of the chapters include a story (invented by Ramadas) structured around a girl (Mini) and a boy (Apu), who appear throughout the books. The girl is active, coming up with questions and answers, and both of them take the initiative and do things." Such seemingly minor interventions into cultural mores can have a huge impact.

Ramadas also saw it as key that the books should be accessible to as many children as possible and so they have been designed in black and white so they can be printed at very low cost. In addition, extracts of the books are downloadable free of charge from the 'Small Science' website. The experiments, too, are very simple and the required materials are cheap and readily available.

LOCAL PUBLISHERS

'Small Science' has been published and distributed by Oxford University Press for the last five years, but HBCSE has recently signed a contract with a local Indian start-up company, InOpen Technologies, based at the Indian Institute of Technology (IIT) in Mumbai. Ramadas is very optimistic about this development, since it will ensure the publishers have a more hands-on approach to promoting the textbooks, and will allow the authors and practitioners to maintain contacts with the schools, receiving valuable feedback that they can then follow up on to help continually improve the series.

"By offering help and support to teachers, especially in the initial period of adoption, we hope that InOpen and HBCSE together will help to seed a community of practising teachers who interact and exchange ideas on academic issues. We hope that InOpen will document the implementation of 'Small Science' in schools and in that process create more support material for teachers. Over the last ten years some schools and teachers have been using 'Small Science' on their own initiative and enjoying the experience.



LASTING IMPACT

Ramya Mohan, a student who is now in college, recalls from her school days, "'Small Science' was the first book that was compelling to me. It didn't just have a to-the-point chunk of text with a few illustrations – instead, it had poetry, recipes, tips, amusing stories. All this was designed to engage and stir the curiosity of a child. It was a breath of fresh air. The books opened my eyes to a whole new way of learning – one I wish was implemented across all schools."

We hope that this group grows and flourishes with InOpen's help."

Ramadas is now particularly happy because a teacher who has successfully used the textbooks, Gunvant Jain, has recently joined InOpen. Ramadas is hopeful that, since Jain has had such a positive hands-on experience, he will be able to effectively and enthusiastically market the book to schools and teachers throughout India (see box, p. 34).

Rupesh Kumar Shah, founder and CEO of InOpen Technologies, shares Ramadas' optimism. "InOpen is currently in discussion with agencies to implement the use of 'Small Science' across schools in India", he confirms.

In fact, looking at the quality, thoughtfulness and immediate relevance of these beautifully presented books, it really would be a shame if they were not more widely adopted, not just throughout India, but as models of good practice in teaching science throughout the world. Let us hope that InOpen really do a good job promoting and distributing the books so that developing and developed countries alike can build on the solid but stimulating foundations Ramadas and her fellow educators at HBCSE have worked so hard to put down, and to supplement them with their own specific national, cultural and geographical examples. Ramadas' research, commitment and teachings go a very long way to ensuring there is an enquiring – and receptive – base of young minds on which to build science capacity in the South. ■

For more information on 'Small Science', visit: http://coglab.hbcse.tifr.res.in/