SCIENCE EDUCATION FOR RURAL CHILDREN: FOCUS ON THE MIDDLE SCHOOLS IN THE DEVELOPING WORLD*

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Science literacy standards and school level science education efforts are primarily directed to meet the needs of the urban children until the age of fifteen. Yet globally, more children live in rural areas and are deprived of basic education and of a chance to have a promising future. Here we outline some core issues that demand attention and explore how physicists may be able to contribute to the science education of the rural children.

1 Rural children of the developing world

Science education is crucial to developing a technologically trained workforce in the industrial and developing world. But is that all? The developed world consists of about 0.9 billion people in some 50 countries, a small fraction of the 6.47 billion world population. About 5 billion people live in the 125 low and middle income developing countries and 0.4 billion are estimated to live in countries in transition. Some 3 billion people in the developing countries live in rural areas, with 1.2 billion living below the poverty line and earning less than $1/day. The Food and Agricultural Organization (FAO) estimates that there are 130 million out-of-school children and 880 million illiterate youths and adults [1]. Science education and training are two of the most powerful weapons in the fight against rural poverty and for sustainable development. Basic physics education is a necessity for understanding "how things work" in an increasingly mechanized world and hence plays a prominent role in science education for children. Perhaps nowhere is the importance of science and physics education for the rural poor more recognized than in India [2-5].

It is not surprising that the science education needs for urban and rural children are different. Here the word "rural" is loosely defined. By rural children, we include the children who live in the urban slums. The urban slum children may have more schools in close proximity, but they often work and their lives are so constrained that they can seldom access these educational opportunities in their vicinity.

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The urban child will typically spend a significant fraction of his or her early life attending elementary (Kindergarten – 4th grade), middle (5th - 8th grade) and high (9th-12th grade) schools before attending college. The curriculum for the urban child is broadly consistent with the science literacy standards as developed for example in Project 2061 of the American Association for the Advancement of Science and endorsed by many nations [6]. There are countries, such as India, that have their own science literacy standards that are similar to the US standards. However, these standards are not quite designed to address the educational needs of the rural child. The rural child might attend elementary school but the educational experience is unlikely to stretch much beyond the middle school level. Many rural children also work and hence their school times are limited compared to that of their urban counterparts. Further, these children often fall behind in school. A typical group may hence have significant age disparities that can affect the social dynamics in a class room environment. An experienced educationist, Sujit Sinha, who is the founder and director of a major Non-Governmental Organization (NGO) in West Bengal, India, called "Swanirvar," has remarked that it could well be that high school and college level education does not help the student achieve success in the rural setting. Many students who can attend high schools and even college may find themselves as misfits in both the urban and rural environments. While some surveys to examine the proportions of rural children that attend elementary, middle and high schools and those who become productive members of the rural communities would be desirable, there is little question that middle school education could well be the key window of opportunity to empower the rural child.

2. Science education at the middle school level in rural India

In spite of formidable constraints, India has made tremendous strides in educating rural children in the last thirty or so years. In this journey, Vinod Raina has played a role of singular importance. According to Raina, India has some 200 million children of school-going age attending elementary and middle schools (i.e., age 6-14). It is estimated that some 80 million of these children either "never enrolled" or are dropouts. Child labor ranks as the third most important reason for dropouts. The achievement levels of the remaining 120 million school going children in the elementary school level are also poor. Raina argues that only 20% of these children achieve acceptable norms of numeracy and reading/writing skills by the fifth grade. Differences between states do not seem to be much of an effect [7]. Nevertheless, a large number of NGOs are actively working with the teachers and the state governments at the grassroots level, using the television, the internet, indigenously developed texts and on occasions with mobile laboratories to educate rural children. The focus is on elementary schools. There is a clear need to expose these children to some effective form of middle school education.

The standard curricula for middle schools, as found in the science literacy maps, follow a strong "bottom up" approach. Concepts are introduced often at very early stages, such as in the first or second grade and then developed by revisiting the same in greater depth in the upper grades. Connections between topics are also exposed through this development process. This approach is obviously effective as it allows for the time

taken to absorb and develop each topic. The approach is also detail oriented and designed to prepare the student for advanced studies in traditional topics in the sciences and engineering, in medicine, business and the social sciences and humanities. In recent years, there has been a strong push to address cross-cutting topics. However, the curriculum is not of much direct value to the rural child. Examinations are designed to measure learning. Another way of viewing the system is that it is a "survival of the fittest" approach. The system in effect selects the most capable.

Rural children have more responsibilities than typical urban children and have limited time for school. It is likely that most of these children would not attend high school. Hence, the middle school would typically be their last formal educational experience and their only opportunity to learn about the basics of sustaining village life, to learn about the topics that would help them become productive rural citizens and help sustain the future rural economies. What would the rural child want to learn? At this point it is clear that in the context of learning basic physics, learning about measurement and about how to appreciate the principles of mechanics and of electricity and magnetism

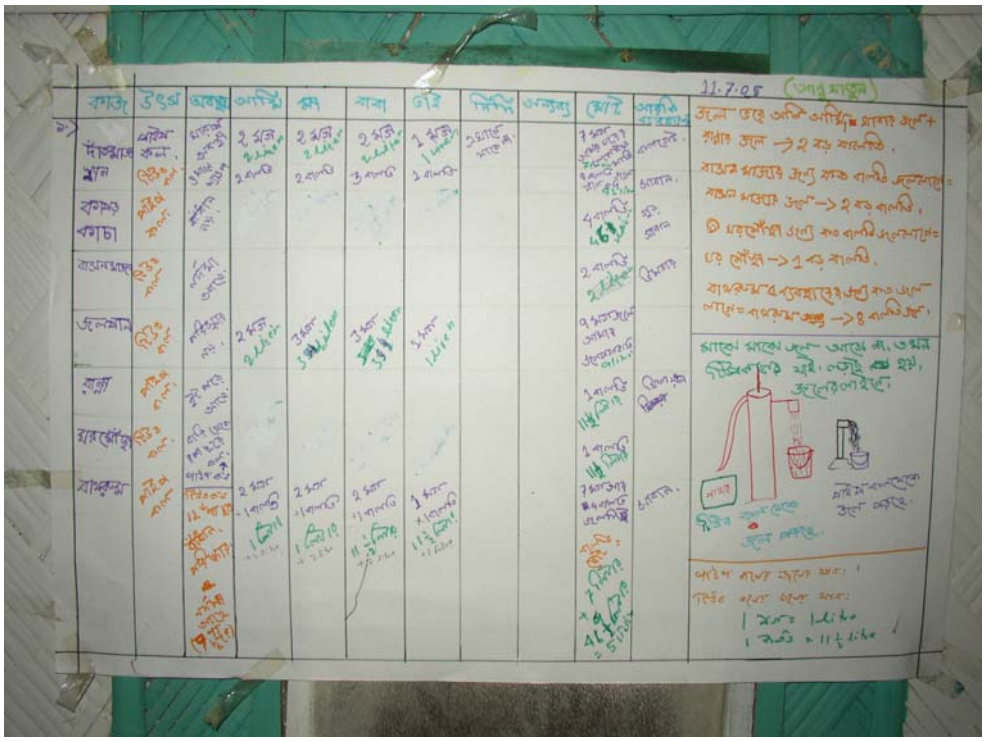

Figure 1: The chart above depicts how rationed water is used for various household activities by the family members of a child. The chart has been done by the child who is from a slum in the New Alipur area of Kolkata, India. The work was performed as part of the activities in a school that is operated by Sujit Sinha and is designed for the slum children. There are no sharply defined grade levels in this school. There are children at the beginning and intermediate levels. In each group there is quite a wide variation in the ages of the children, which can sometimes makes classroom management a challenge (Photo by Surajit Sen, 2005).

in common toys and machines would be very important for them.

The usual way of learning mechanics through kinematics, Newton's laws, energy, rotational dynamics, oscillations, etc., or electricity and magnetism starting with electrostatics and covering fields and circuits and induction, etc., even if the programs were to include laboratory based education, could be inappropriate for their needs. They would not only be under-prepared for such topics at such an early age, it could be difficult for most students to even connect with the way these topics are taught in the urban classrooms – and that too usually at a much higher grade level. Further, it would be extremely expensive to provide such education to a segment of the world population that is so very poor. Simply put, the current school system is not designed for educating the rural child.

On the other hand, if the middle school level fails to provide some appropriate opportunity to these children to learn about basic science and theory, the children would be forever deprived from basic and higher education. How then does one strike a compromise? What kind of resource bases do we currently have? There are no easy answers at this stage but a debate is needed. Some of these issues were examined in a workshop titled Indo-US Workshop on Peer Reviewed Online K-12 (10+2) Science Education (PROKSE) held in July 2003 in Nagpur, India [9]. A recent informal workshop held in Delhi in August 2005 further developed the ideas put forth in the PROKSE workshop. The deliberations in both of these workshops revealed that efforts to reach the rural children must be carried out by empowering the teachers who directly interact with these children. Further, the instruction must be such that children can relate to their environments and their surroundings. For instance, many of the topics in physics can be introduced to the middle schoolers with appropriate contextualization. Thus, a "top-down approach" is presumably better than the traditional "bottom up" approach pursued in traditional science education curricula. The importance of measurement acquires obvious importance when a child realizes that measurement is important for defining land ownership or that tabulating data in columns and graphing is important for getting a quick overview of something as simple as water usage as a function of the number of people in the family (see Figure 1). The fascinating behavior of common toys can be used as a way to introduce the laws of mechanics, fluids, electricity and magnetism and thermodynamics. The sky can be used as a way to contextualize processes such as evaporation, cloud formation, rain, why the seas are salty and the rivers and lakes are not, pollution, lightning and even why the Universe has a finite age [10].

It was also clear that there is an urgent need to assess appropriate materials that may already be available for rural middle schools.

3. Resources for rural middle schools

An invaluable source of available textual materials in downloadable form is Arvind Gupta's website [11]. This site not only contains Gupta's own books but also many others that are useful for middle school children. There are many resource bases that remain as little known hard copies that are circulated by the talented and creative teachers in many NGOs [12-13]. These books differ in the materials they cover, the languages in which they have been prepared and also in who they are the meant for – namely whether they are to be used directly by the students or whether they are designed

to train the teachers and would be of limited value to the students. Efforts to digitize these books are currently being pursued by several groups in India and it is expected that within several years, much of these materials would be available online at no cost or at minimal cost. Rural communities across the developing world stand to benefit from these efforts. However, rural education is geared towards empowering the children of rural communities and for insuring that these children can eventually become productive rural citizens who would help sustain rural economies. Rural science education is not a "one size fits all" endeavor. We all know about the importance of water no matter where in the

Figure 2: (Left) Group project work in progress at a school run by Swanirvar in Northern 24 Parganas of West Bengal. (Right) The board presents the names and medicinal values of various commonly available plants in northern 24 Parganas district of West Bengal, India.

world we live in. However, contextualizing the importance of water in a tropical area in a given language could be very different than doing the same in the same country but in the high desert. Teaching about birds and insects and trees and food also need the same degree of linkages with the geographic coordinates of the community for whom the books are meant (see Figure 2).

In great many villages, the television serves as a link with the external world. Nowadays, community education centers with internet connectivity have emerged in many developing countries. There is little doubt that within the next several years, this connectivity will only increase. Soon, the world's rural areas will become wired. The pervading presence of the internet and the television will open up promising possibilities for educating the rural children and the adult alike.

In addition to text books, digital libraries such as in http://www.merlot.org, http://nsta.org, provide a wealth of resources. Although most of the resources are available as applets that enhance understanding of traditional chapters in college level textbooks, there are items dedicated to elementary, middle and high school levels that are slowly flowing in (e.g., http://www.middleschool.net/curlink/math/mthmain.htm, http://www.getsmarter.org and http://www.whyville.net/top/index.html). Development of connectivity between these items and filling in the gaps need to be done.

4. Summary and conclusions

In this article, we summarize the plight of the poor rural children in the developing world and justify why the educational needs of these children are so important and so different than what the traditional education system has to offer. We focus on science education and point out that the need for contextualization of the educational materials and practical limitations demand that instead of teaching science via individual disciplines, there is a need to teach science on the basis of what the child experiences in the immediate environment. Further, the educational materials need to be in the spoken language appropriate for the rural area and above all needs to be inexpensive enough to be affordable. Science education in the rural context needs to be systematically addressed by the fortunate.

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10. See for example, B. Ryden, *Introduction to Cosmology* (Addison-Wesley, San Francisco, 2003) p. 8.
11. A. Gupta and his collection of books in English, Hindi and Marathi can be found in downloadable form in http://arvindguptatoys.com/. For example, for an informal study of shapes, geometry, hands on model building and the ideas embedded in

many simple machines, see A. Gupta, *Toy Treasures* (Eklavya, Bhopal, 1993), and for a book on how to make the simplest pump and the attendant physics of fluids in a most non-technical way see, S. Vaidyarajan and A. Gupta, *Pumps from the Dump* (Vigyan Prasar, New Delhi).

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