IDB Education

BRIEFLY NOTED

No. 7 • DECEMBER 2010

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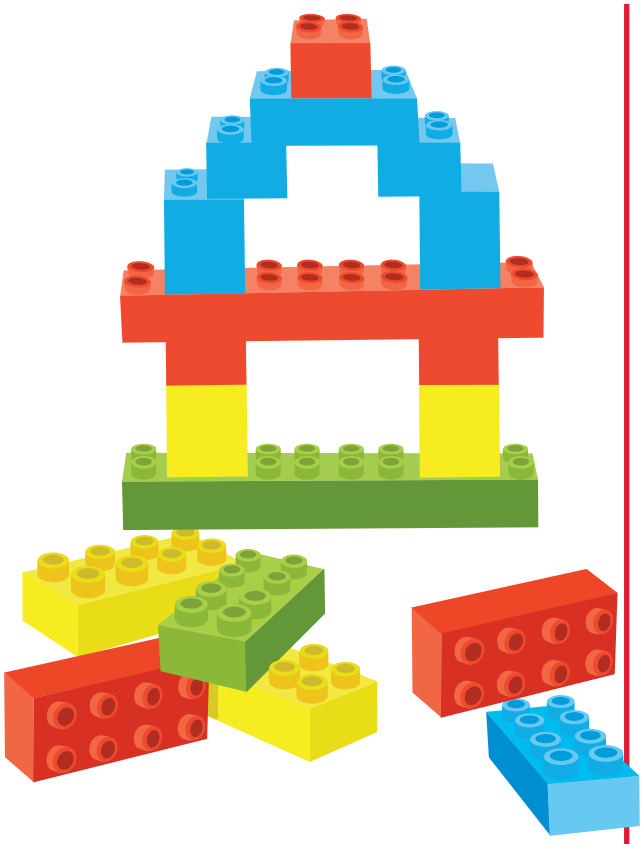
BUILDING A FUTURE OF INQUISITIVE SCIENTISTS IN PERU

Summary: Peru's Ministry of Education has partnered with the Inter-American Development Bank (IDB) and LEGO Education to develop a program that helps children improve their ability to solve scientific problems using a set of curriculum materials that is affordable and can be brought to a national scale. Working in teams on problems that capture their interest, students devise solutions, reflect on what they build while solving the problem, and apply what they have learned to new challenges. This brief describes a pilot initiative and its evaluation design and baseline.



Peruvian Kids Underperform in Science

Students from Peru perform below students from most other countries on international standardized tests in mathematics and natural science. Peruvian students had the lowest scores in these subjects among all Latin American and Caribbean countries participating in the 2009 Programme for International Student Assessment (PISA). Fewer than 3 percent of Peruvian students managed to achieve the average levels of students from the participating "Asian Tiger" economies (OECD 2009). These poor results were repeated in achievement tests at the regional and national levels.[1] The failure to develop numeracy skills is particularly pervasive among students from poor households (Duarte, Bos, and Moreno 2009). Inequalities in student achievement are also apparent by gender: boys score higher than girls in natural science (LLECE 2008).

The poor outcomes in science and mathematics are the result of large gaps in the quality of the teaching force. A national evaluation in 2007 found that 46.8 percent of teachers could not even perform basic arithmetical computations or reproduce routine and short procedures (MINEDU 2007). A study of the mathematics notebooks of sixth-grade students in 22 public schools in Lima revealed that teachers overemphasize the least cognitively demanding topics and assign learning tasks that require little cognitive effort. Students commonly receive no teacher feedback—or worse, erroneous feedback (Cueto, Ramirez, and Leon 2006).

Edited by Steven B. Kennedy • Design and layout by Laura C. Johnson

The poor quality of education in mathematics and natural science in Peru and the low scores of Peruvian students are troubling in view of the country's strong economic growth and the growing demand for a more mathematically and scientifically literate workforce. To function effectively in life and in the labor market, Peru's children will need a higher level of numeracy than that of their parents and grandparents. But students who fail to develop numeracy skills early on have trouble remaining in school and reaching higher levels of education (Valverde and Näslund-Hadley 2010).

Piloting an Inquiry-Based Science Approach

The government of Peru, cognizant of the need to strengthen the country's numeracy education to prepare all students to use mathematics and science effectively, included among the goals of the country's 2009 primary education curriculum the "development of mathematical thinking and a scientific and technological culture." As a step toward the achievement of that goal, the ministry in 2008 requested assistance from the IDB to develop and validate a pedagogical approach for third-grade education in science and the environment. The two institutions joined forces with LEGO Education to develop an affordable pedagogical model that lays a strong foundation for future learning by providing Peruvian children with hands-on experience in science and environmental studies.

Initial testing of the Science and Environment Education Model was carried out in 2010 in 10 provinces and 62 districts of the department of Lima. The areas were selected based on socioeconomic characteristics and educational results. All districts have a high proportion of households with unmet basic needs and students who scored at the lowest level on the 2008 national student assessment. The sample was stratified according to school size, level of urbanization, and type (graded or multigrade). The 106 public primary schools in the targeted districts were randomly assigned to treatment and control groups of equal size. Participating in the pilot are 4,986 third-grade students and 203 teachers, roughly half of whom are in the treatment schools.

The effectiveness of the model in improving on the baseline will be evaluated by Innovations for Poverty Action, a nonprofit research organization. The evaluation is designed to assess the effects of the program model on student achievement and on teachers' perceptions, substantive knowledge, and pedagogical skill. In addition to assessing the experimental research, the evaluator will also conduct a qualitative evaluation of the program, including the monitoring of the intensity of application of the model.

Tapping into Children's Creativity to Improve Learning

Research has proven that learning is improved when children acquire first-hand experience with the issues they are studying. When students can work directly on a science problem, they build their own knowledge base (Inhelder and Piaget 1958; Duckworth 1987). But because laboratories and sophisticated equipment are beyond the reach of most Peruvian schools, science education tends to focus on theories, with limited opportunities for practical applications in the classroom. The challenge of the pilot program was to equip schools with low-cost curriculum materials that are compelling enough to inspire children to conduct hands-on experiments.

To teach science through inquiry, teachers need access to materials such as containers, chemicals, scales, and living organisms. From among many producers of science materials, the LEGO primary-level science set was identified as an appropriate tool for the implementation of the program model. It was combined with additional tools and supplies for the biology and chemistry modules, providing a rich science kit that stimulates students' curiosity and is easy to relate to their everyday life. The kits enable students to investigate important science concepts in depth without access to a school laboratory. Thanks to a donation from LEGO Education, all beneficiary schools were equipped with the kits. The kits are affordable and should be possible to bring to scale in Peru.

The government of Peru wants to use the new science and environment approach to bring innovation to the classroom. Students are organized in teams and presented with open-ended tasks linked to challenges that either relate to experiences from their everyday lives or are so enticing that they inspire children to explore further: Why does grass feel wet in the morning? Why is Lima always covered in fog? What are hiccups and why do we get them? Rather than lecturing, the teachers are tutored to play a role as facilitators who help students approach their challenges by suggesting entry points and learning tasks.

Pedagogical Knowledge of Teachers (%)

Perception	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	No response
The primary function of the education system is to transmit reliable data in different areas	16	52	7	9	0	16
Science education is primarily a matter of memorizing facts	1	17	28	37	7	10
Students must first learn the theory of science before engaging in scientific inquiry	12	38	15	22	3	10
Students learn science if they pay attention to teachers' explanations of scientific concepts	17	39	13	18	1	11

The approach encourages students to find and explore their own solutions through the use of science, mathematics, and communication. After working out their solutions, students are urged to think about what they have achieved. Teachers then provide students with ideas that extend their knowledge.

Baseline Findings: A Troubling Picture of Science and Environment Education

Data collected just prior to the launch of the pilot offer a troubling picture of science and environment education in Peru. Fewer than 16 percent of school principals reported that their school had enough textbooks; fewer than 17 percent indicated that they had enough pedagogical literature for teachers. Fewer than 9 percent said that the school had enough materials to teach geometry or conduct science experiments. More than 70 percent of teachers had not received any training in science and the environment in the past 10 years. The lack of training is reflected in important gaps in teacher knowledge and in their perceptions about science and the environment.

Three-fourths of the teachers believe that the primary function of the education system is to transmit facts (see table above). It is not surprising, then, that fewer than half of the teachers disagreed with the idea that science education is primarily a matter of memorizing facts rather than developing scientific reasoning and problem-solving skills, that 50 percent of teachers believe that students must first learn the theory of science before engaging in scientific inquiry, and that 56 percent believe that students learn science if they pay attention when the teacher explains scientific concepts.

The lack of training is also reflected in teachers' outdated perception of the discipline of science. Three-quarters of teachers stated that natural science is a body of accepted truths that explain mainly natural phenomena. More than half had an outdated view of what scientists do.

On average, students are far from grade-level achievement in natural science: fewer than 10 percent showed grade-level knowledge and skills.[2] Results were slightly higher in the Lima metropolitan area than elsewhere. There were no significant differences between boys and girls.

Next Steps

Tests will demonstrate whether coaching children to be curious about the world around them and to search for solutions to problems will translate into achievement gains. The next steps are to implement the model for a full academic year and evaluate it rigorously through an experimental design.

Key characteristics of the Science and Environment Education Program

- Children learn best when they can relate new experiences to their existing knowledge or when they are exposed to something so interesting that it motivates them to investigate it further. Therefore, the program model presents children with challenges designed both to take advantage of their everyday experiences and to capture their interest.
- To increase the motivation to learn and foster the development of learning communities, students work in teams to develop their own solutions to science problems.
- Students are given time to reflect on their solutions and adjust their ideas.
- To help them enter an upward learning spiral, students are presented with follow-on ideas and encouraged to apply their new knowledge to additional challenges.
- Lessons are planned based on the knowledge and competencies in science and the environment that students need to master, and on assessments of what they already know.
- Instruction is diversified to address the needs of all types of learners, providing different entry points, learning tasks, and outcomes tailored to individual needs.
- Although the pace and path of learning will differ from one student to another, the teacher must believe that every student can learn. The expectations for every child must be high.
- Teachers who receive support and training are more likely to engage enthusiastically in a science program. The new program includes in-class tutoring to ensure that teachers receive hands-on support during the switch to a child-centered approach.

Notes

1. On the Second Regional Comparative and Explanatory Study (SERCE) in third-grade mathematics more than half of the student population reached only the very lowest achievement level (LLECE 2008). On the 2009 national mathematics test, just 13.5 percent of second-grade students met national targets for their grade (Unidad de Medición de la Calidad Educativa 2010).
2. Because the baseline data were collected at the beginning of third grade, students were tested on second-grade content.

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