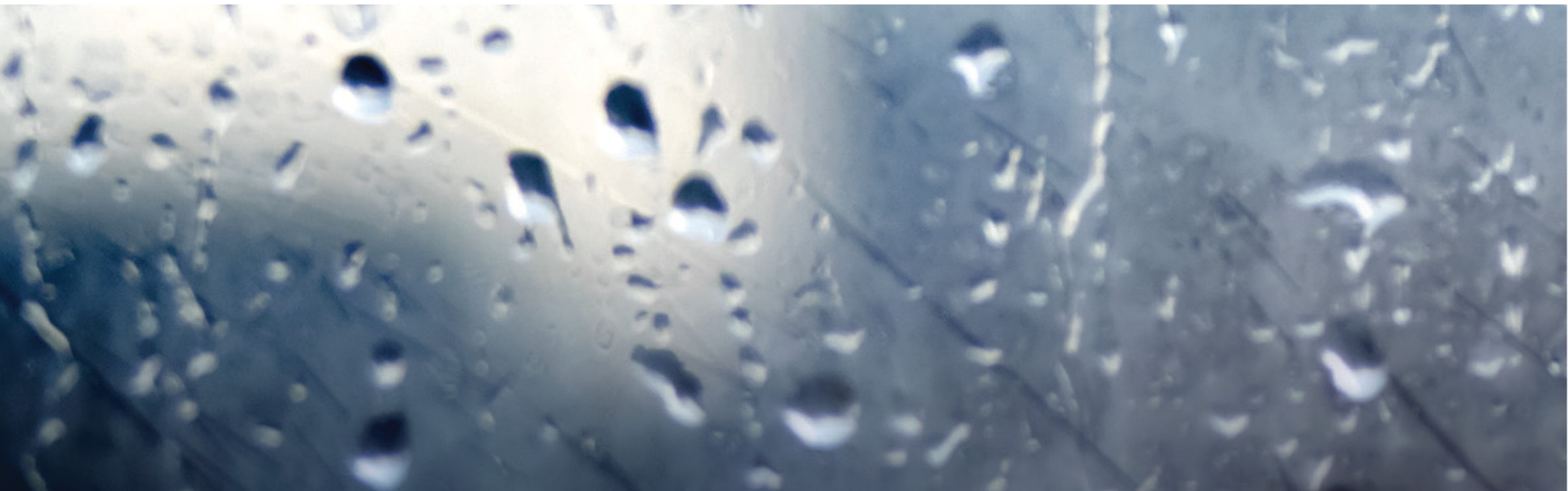


Inquiry-based learning

Assessing students' science inquiry skills

INQUIRY-BASED APPROACHES TO TEACHING YIELD SUBSTANTIAL BENEFITS TO STUDENTS, BUT ASSESSMENT OF STUDENTS' SCIENCE INQUIRY SKILLS INDICATE MORE EMPHASIS IS NEEDED ON THE DEVELOPMENT OF INQUIRY-BASED TEACHING AND LEARNING IN THE CLASSROOM. **ABHA BHAGAT** REPORTS.

Research indicates that inquiry-based approaches help students to acquire 21st century skills in reasoning and critical thinking.

Research in 2014 by Ralf Greenwald and Ian Quitadamo, for example, found that students taught using inquiry-based methods made gains two-and-a-half times greater in critical thinking than those taught using conventional methods. Inquiry-based teaching methods also produced a final exam performance 12 per cent greater and grades on a common grade performance benchmark 11 per cent higher than conventional methods.

Inquiry-based teaching has particularly gained momentum in science, where research increasingly indicates that inquiry modes of instruction promote better learning and understanding of scientific concepts.

Benefits of inquiry-based learning

A comparison by Chun-Yen Chang and Song-Ling Mao of learning outcomes in science classes using inquiry-based and conventional methods found that inquiry approaches promote students' achievement by enabling students to plan their own investigations, gather and interpret data, share information, make and reflect on these inferences through small-group activities and discussions. Moreover, research by Aisha Kawalkar and Jyotsna Vijapurkar reveals evidence that students remain actively engaged where classes use inquiry-based compared to conventional methods, and pose more questions reflective of higher order thinking, with research by Erin Marie Furtak and colleagues also finding positive correlations between inquiry-based teaching and student learning of science.

According to Kathleen Chamberlain and Christine Corby Crane in *Reading, Writing and Inquiry in the Science Classroom*, Grades 6-12, for example, inquiry-based instruction has enhanced students' laboratory skills as well as skills in interpreting data and critical thinking.

Ronald Marx and colleagues at the University of Michigan, in a partnership with Detroit Public Schools, implemented an inquiry-based approach to science units with students in Class VI to VIII over three years. Exploring force, for example, the students were asked to investigate the question, 'How can I move big things?'

Marx and colleagues tested 8,000 students before and after the curriculum, finding that participating students made statistically significant gains in terms of understanding content and process, and overall achievement.

Scientific inquiry incorporates a broad range of skills. These include observing, measuring and recording data; processing and analysing data; posing questions related to scientific phenomena in everyday life; identifying and investigating scientific problems; making appropriate conclusions based on evidence; and evaluating, collaborating and communicating ideas using a variety of tools. These skills are fundamental in assisting students to perceive and understand their surroundings from a scientific perspective, including understanding biodiversity, environmental impacts, and health and hygiene.

In preparing students for a complex and changing world, we need not only to teach using inquiry-based methods but to know whether students are acquiring critical thinking and problem solving skills in order to succeed in work, life and citizenship.

Assessing critical thinking and problem solving skills

To assess science inquiry skills we need an assessment in the context of science content and cognitive domains, as Ina Mullis and Michael Martin note in their examination of the assessment frameworks that underpin the Trends in International Mathematics and Science Study.

In classroom practice, however, it is often difficult and time consuming to design questions that assess inquiry skills, and teachers often require specialised training and resources to assess these. To address that, my own study has evaluated the science inquiry skills of students from Class V to VIII in the light of the available data on students'

performance from the International Benchmark Test (IBT).

The IBT is a large-scale assessment from the Australian Council for Educational Research, publisher of *Teacher*, for students in Classes III to X in English, Mathematics and Science conducted in schools in India, the United Arab Emirates, Malaysia and South Africa.

Benchmarking the evidence

My study used IBT multiple-choice questions designed for students from Classes V to VIII to assess science inquiry skills. The multiple-choice distractors in the IBT are carefully designed to identify students' understanding and misconceptions. The IBT is prepared collaboratively by a panel of subject matter experts. A psychometric analysis of students' performance based on the Rasch model is conducted in order to report student achievement levels in terms of developmental scales for each subject.

For my study, the performance of students from Class V to VIII on questions that assesses science inquiry skills was analysed, namely:

- ability to read and interpret information on a graph
- ability to evaluate and suggest improvements
- ability to identify a scientific problem
- ability to make scientific predictions, and
- ability to make conclusions based on evidence.

Results from the IBT indicate that Class V to VIII students in the test sample have a moderate ability to read and interpret bar graphs correctly, but also that there is no significant improvement in this skill as students move from Class V to VI to VII and VIII. At Class VIII, 50 per cent can read a simple line graph. Students can identify a single piece of information on a graph but find it difficult to identify patterns or trends indicated on the graph.

In terms of their ability to evaluate and suggest improvements to an investigation, 60 per cent of students at Class V are unable to understand the variables involved in a simple experiment related to dissolving salt in water at varying temperatures. Similarly, around 50 per cent are unable to identify a scientific problem when presented with a real-life context related to understanding the purpose of a simple day-to-day investigation.

Students at Classes VI, VII and VIII struggle with questions based on science inquiry. More than 60 per cent of Class VII students cannot make a scientific prediction related to the outcomes of a context involving the concept of camouflage in animals. Students particularly have difficulty drawing conclusions based on evidence and in general more than 60 per cent lack the ability to think critically and make conclusions based on observations.

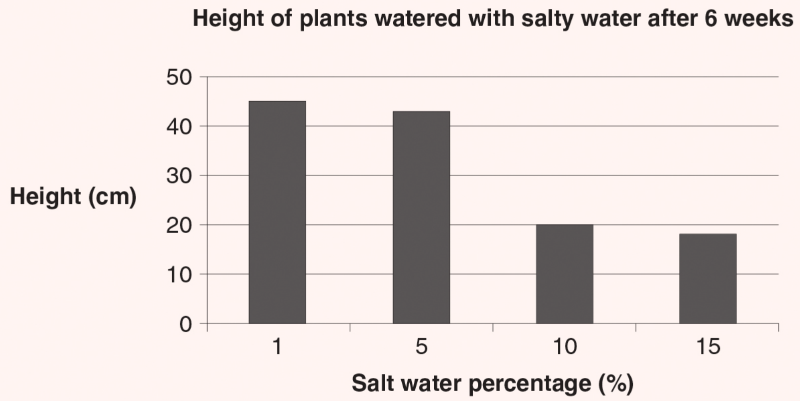
Challenges in adopting an inquiry-based approach

These findings suggest there is room for improvement in implementing an inquiry-based teaching approach, at least in terms of students' abilities to undertake scientific inquiry.

One of the difficulties in implementing an inquiry-based teaching approach is that there is substantial variation in what educators mean by inquiry-based teaching, and a lack of understanding of the skills required to help students generate their own inquiries and guide rather than direct the investigation that follows.

Inquiry-based teaching requires planning and skills in:

Ahmed watered four plants of the same type with salty water.
Each plant received a different amount of salt in the water.
He measured how tall the plants grew.
Ahmed graphed his results after 6 weeks.



14 Which is the best conclusion Ahmed can make from his graph?

- **A** Salt water always stops the plants from growing.
- **B** The plants watered with more than 5% salt do not grow.
- **C** The plants grow best with a small amount of salt.
- **D** More than 15% salt in the water would kill the plants.

Fahim measured the mass of two objects: a cotton ball and a sponge.
He soaked the objects in a bucket of water for one minute.
Fahim took the objects out of the water and measured their masses again.

	Mass when dry	Mass when wet
Cotton ball	22 grams	26 grams
Sponge	25 grams	35 grams

1 What was Fahim trying to find out?

- **A** Which object absorbed the most water.
- **B** Which object looked the wettest.
- **C** Which object had the greatest mass.
- **D** Whether objects change colour when wet.

- providing students with learning experiences that stimulate curiosity and inquiry
- developing relevant and individualised questioning sequences that guide students in their own appropriate inquiry-based learning
- managing multiple student investigations at the same time
- continuously assessing the progress of each student as they progress from formulating inquiry questions to articulating detailed answers, and
- responding to students' emerging queries and providing inquiry-based support when they turn down blind alleys or reach an impasse.

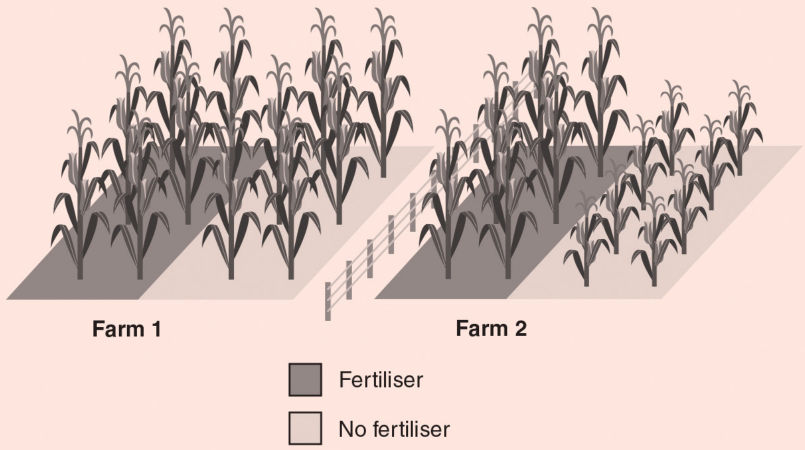
Teachers need professional learning not only in inquiry-based teaching techniques but also in understanding *how* students learn.

Research suggests that engaging, carefully planned instructional lessons also

Two farmers each used fertiliser on **half** of their field. Both farmers planted corn on their **whole** field.

On Farm 1 all the corn grew tall.

On Farm 2 only the fertilised corn grew tall.



39 What is the most likely reason for the differing results on Farm 1 and Farm 2?

- **A** Farm 2 did not get the same amount of sunlight.
- **B** The soil on Farm 1 did not need the fertiliser.
- **C** Farm 1 got more water than Farm 2.
- **D** Farm 1 did not get as much fertiliser as Farm 2.

remain important. Overall, the message for teachers and students is that science is not simply a body of knowledge to be learned, but a way of thinking and problem-solving that can be applied to a range of real-life situations. **T**

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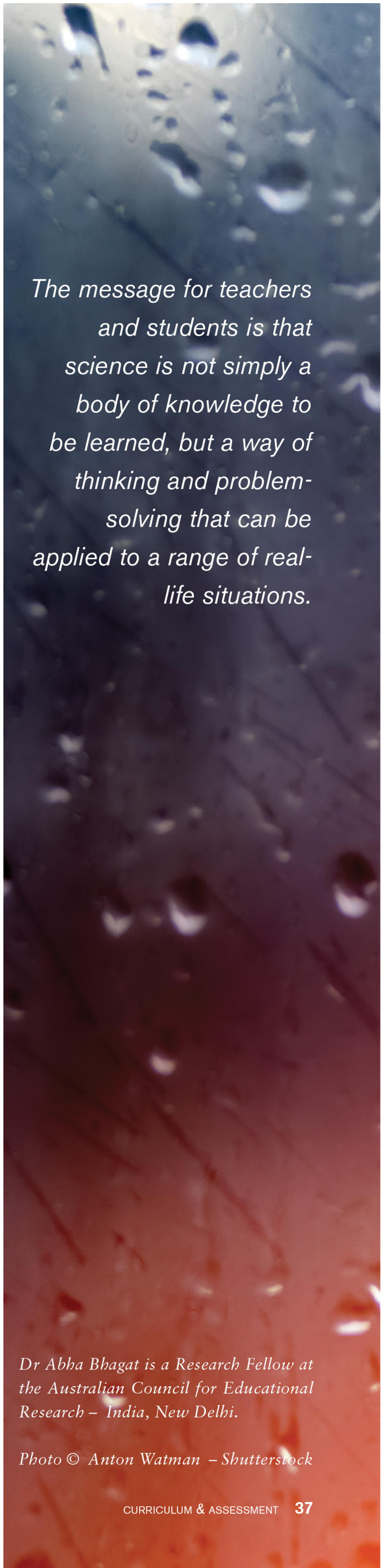

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