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This issue of ReEd focuses on the learning of Science in Singapore classrooms. Science education in Singapore is internationally recognized for its successes in TIMSS and PISA.

While we celebrate our students’ successes in these international comparative studies, we are cognizant of the need to continuously improve and reinvent ourselves in Science teaching and learning.

The research featured in this issue brings our attention to two key players in the arena of Science teaching and learning: the teachers and their students. In education, the close partnership between teachers and students is important to the success of any learning experience.

As such, we persist in our efforts to examine how teachers can develop a more acute sense of their practices.

This ranges from developing their pedagogical content knowledge to increasing their repertoire of strategies for formative assessment, learning how they can create scenarios to excite students into realizing their knowledge gaps, to creating opportunities for students to engage in authentic science research, and finally, harnessing students’ natural curiosity about the world to excite them to learn Science.

With teachers’ continuous effort to improve their practices, we hope that students will respond by being partners and co-designers in creating meaningful science learning experiences.

We envision that students will become more scientifically literate, develop a more critical sense of responsibility to their environment and become more informed consumers of science. These are no small feats in the ever-changing educational landscape where Science is merely one of the many subjects that students learn in a crowded curriculum.

As such, continued and sustainable research into how students and teachers interact in Science classrooms and laboratories remain fundamental and important in our broader educational landscape.

As we strive to improve and innovate our practices, we need to ask ourselves whose interests we are serving. Further, how can success or attainment of our practices be evaluated?

We hope that the issues raised by our researchers about Science teaching and learning in this issue will put us in a more reflective mood about our practices in the Science classrooms and laboratories.
Co-constructing the Science Classroom

PROJECT TEAM

Principal Investigator  Tan Aik Ling, National Institute of Education, Singapore
Co-Principal Investigator  Shirley S. L. Lim, National Institute of Education, Singapore
Researcher  Frederick Talaue, National Institute of Education, Singapore

HOW SHOULD LEARNING and teaching Science look like in the 21st century? Should the teachers or pupils decide what is considered learning? Associate Professor Tan Aik Ling says both should play a part.

“The partnership between kids and teachers is important,” says Aik Ling. For authentic learning to occur, the understanding between teacher and student needs to be mutual.

Correcting Assumptions  As the Science syllabus shifted its focus to an inquiry-based approach in 2008, Aik Ling and her team thought it opportune to find out how primary school classrooms were adjusting to the Ministry of Education’s effort to develop scientific curiosity in pupils.

What they found was that even though the new syllabus demands new ways of engaging kids, the teaching methods used were still largely instructional.

“There were low levels of inquiry,” says Aik Ling. “Lessons were based on the previous mind-set about learning and how Science learning ought to look like.”

However, for real inquiry to take place, the learners also have to play their part and take ownership of their own learning. Partnerships and dialogues have to be created between teachers and pupils.

Dialogues about Learning  To get teachers and pupils on the same page, the research team recommends co-generative dialogues.

They used a simple, short video clip of a lesson to kick off the dialogues. By letting pupils voice aloud what they thought of the lesson, teachers had the opportunity to understand the learners’ point of views. Three main points emerged from these dialogues.

First, pupils did not always understand the intention of certain activities. Second, they had a lot of ideas about how lessons can be conducted but did not articulate them during the lessons. Third, pupils did not necessarily know how to work in groups even when they are in one.

Lived Experiences  “These are not groundbreaking findings,” says Aik Ling, “but these are the lived experiences that the kids take home about what Science and Science learning are about.”

Aik Ling’s goal is simple. She would like to see more learners having the chance to help construct the lesson so that they can learn better about a particular topic.

“If teachers are listening to what the kid’s experiences are, they can shape their lesson planning and teaching to take into account what students can then take home,” she says.

“Do we want students to remember the bad points of a lesson such as resolving groupwork disputes,” Aik Ling asks, “or do we want them to remember what they had learned about Science?”

At the end of the day, it is every teacher’s dream to give their learners a lesson they will never forget. And with the inquiry approach, this dream can be made a reality.

Aik Ling (far left) and her team (Frederick and Shirley) think it is a great idea to have teachers and learners co-construct lessons together.
Imelda is interested in the development of locally relevant PCK among teachers to bring about more meaningful learning amongst students.

A FORCE is always needed to keep an object moving—this is a common “misconception” that a number of learners tend to have.

To get them back on the right track, do we simply tell them the generally accepted scientific ideas? According to NIE Research Scientist Dr Imelda Caleon, doing so may only create a surface-level change in their understanding that does not last.

“Some students repeatedly use their ‘misconceptions’ when answering the same question, even after their teacher had explained to them that they are not consistent with established scientific views,” notes Imelda.

What will get them to truly learn is the opportunity to process and confront their own misconceptions.

Pedagogical Content Knowledge “We can present various scenarios to generate cognitive conflict among students; that is, these scenarios run counter to their expectations and challenge their personal ideas,” says Imelda.

Only when students feel dissatisfied with their existing ideas and find alternative science ideas reasonable and fruitful will they be ready to change their minds.

To create such learning opportunities for their students, teachers must possess both content knowledge and pedagogical knowledge in a subject. In other words, they must understand not only what they are teaching, but also how it should be taught to learners.

“These two forms of knowledge are often perceived to be separated and taught separately during teacher training,” shared Imelda.

However, she feels that the teachers need to see pedagogy and content as one to make the subject matter more “palatable” to the learner. This merging of content and pedagogical knowledge leads to what is known as pedagogical content knowledge (PCK).

Thinking about Teaching Leveraging PCK to change students’ flawed conceptions is something Imelda is passionate about.

But she feels that there is currently very little research done in this area. She decided to examine how teachers develop PCK in relation to their use of the conceptual-change approach.

Imelda hopes that the locally relevant information on PCK generated from her study can impact the professional development programmes and pre-service courses for teachers in Science.

“It is my wish that through this study, teachers can be encouraged to reflect on or think about how and why they teach specific science ideas the way they do, and how this can be improved,” shares Imelda.

Teachers, both new and experienced, can get together to reflect and share their experiences. “Whilst both beginning and experienced teachers were found to have underdeveloped PCK in the use of the conceptual-change approach, the experienced teachers were found to have more advanced PCK in terms of their curriculum knowledge and familiarity with the students’ knowledge and learning difficulties,” adds Imelda.

With teachers playing a central role in their students’ learning, such professional development would certainly go a long way in fostering meaningful learning among students.
Closing the Knowledge Gap

HOW DO YOU make students curious enough to find out more about something? It may be as simple as getting them to realize they do not have the answer!

“If you give them a problem and tell them to explain it or find the answer, they’ll say, ‘Wait a minute, I don’t know. I have a knowledge gap.’ And their next reaction is, ‘This is interesting, I want to find out more!’ This is a reaction that leads to situational interest,” says Research Scientist Dr Jerome Rotgans.

Situational Interest While personal interests are developed over a long period of time, situational interest is temporary and triggered when students realize there is something they do not know and should find out.

“What happens in education is that this leads to exploratory behaviour. That’s when they start studying,” explains Jerome.

Jerome’s project is about how teachers can create awareness in students about such knowledge gaps. To do that, teachers can create scenarios and get students to make predictions about the outcome.

In this way, they will realize they may not have all the facts. Or students can be asked to explain why something is happening.

To make this approach even more palatable, teachers can add a dash of surprise at the end of their question. For example, a question could go like this:

“If we put an orange and a banana in the water, why is it that only the orange will float? Isn’t that surprising?”

Jerome and his colleagues found that students who were “surprised” in this fashion were much more interested in finding out the answer.

However, after they have gained the information to close their knowledge gap, students’ interest will naturally decline. But if teachers can continue to create situationally interesting problems in Science, such triggering of students’ situation interest over time may lead to a personal, deep-seated interest in Science.

Jerome also found that the students’ long-term retention of content improved remarkably when the situational-interest approach is used. He observed that academically weaker students benefitted from the approach as well. While they did not get the top scores, their learning curve was steeper.

By giving such students authentic and everyday problems, they are able to connect it to the prior knowledge they have and it is more meaningful for them.

Lifelong Learning Jerome believes that this line of research is important because it has a significant impact on students’ learning. If teachers can continually keep students curious to find out more, students will put in more effort and time in the subject, and grow to see its relevance to their lives.

As Jerome puts it, “We have to give students the opportunity to learn something for life and not only for the test. When they learn for life, they make sense of the world around them, and that’s what learning is about.”

Jerome believes that situational interest will eventually lead to changed attitudes and lifelong learning.
Hye-Eun feels that while such questioning is essential, teachers might not always be able to assess their students’ conceptual knowledge using this approach. What they can do is to take a step further and design appropriate activities to assess their students’ level of understanding.

**Going beyond Questions** Instead of questions, Hye-Eun suggests that a teacher could set a scenario for students: Here is a snowman. If we cover it with a thick coat, what will happen to it? Students will make their predictions based on what they know and accompany them with evidence or reasons.

“Teachers should allow diverse explanations even if some of them are incorrect,” Hye-Eun says, and give them time to discuss their predictions with materials provided by the teacher. “Through this process, students will be exposed to the feedback and this will help them to realize the gaps between what they know and what they should know,” explains Hye-Eun.

**Alternative Formative Assessment** As part of her research, Hye-Eun found that the use of two-tier multiple-choice questions (MCQ) can deepen teachers’ understanding of their students’ conceptual knowledge.

She also found that different teachers have different ways of carrying out formative assessment in the classroom.

“Many teachers use quizzes during class and individual consultations at the end of a topic as formative assessment,” shares Hye-Eun.

An example is how some pose questions frequently during a lesson. *What is the unit of heat? What are the differences between heat and temperature?* Students’ answers are then used to gauge their understanding.

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Hye-Eun hopes that by providing constructive feedback to students, teachers can positively influence their beliefs towards Physics. Ultimately, it is the students’ beliefs that will decide the quality of their learning.
An Early Start in Science Learning

**PROJECT TEAM**

**Principal Investigator** Teo Tang Wee, National Institute of Education, Singapore  
**Co-Principal Investigator** Yan Yaw Kai, National Institute of Education, Singapore  
**Researcher** Goh Mei Ting, National Institute of Education, Singapore

WE MAY have forgotten about how curious we were as kids, but children start asking questions about how the world works from a very young age.

In Singapore, formal education in Science starts only in Primary 3, when children are already 9 years old. What Dr Teo Tang Wee and Associate Professor Yan Yaw Kai want to do is to seize on the natural curiosity young children have about their surroundings and start them earlier in science learning.

**Hands-on Learning** The duo from the Natural Sciences and Science Education Academic Group in NIE worked with children aged 6 to 8 and their teachers for this research project on science learning during early childhood and early primary years.

What the researchers did was to design and carry out experiential and hands-on science activities for the children.

For example, they brought the children to the Botanic Gardens to collect dry leaves and asked them to organize the leaves in groups. “Some of them grouped them according to size. Others grouped them by colour or texture.” says Tang Wee. In these activities, they examine the science process skills the children engage in and how they make meaning out of the observed science phenomena.

**A Holistic Education** To develop children more holistically, Yaw Kai, who is the head of NSSE, thinks it is important to introduce scientific thinking to them at a very young age.

While teachers and parents tend to focus on literacy and numeracy during the children’s early years, Tang Wee and Yaw Kai believe that learning science can actually help children develop in those areas.

An observation Tang Wee made during the science activities is that the children have a limited vocabulary for describing what they see.

“Most of the time, when you introduce magnets to students, the first words they will use are ‘stick together’. So we have to teach them the word ‘attract’, and that when the magnets move away from each other, it is called ‘repel’,” says Yaw Kai.

Science makes such words meaningful for children by providing a learning context for them. “Through learning science and through experiential learning, children pick up the words through their contextualized meaning,” says Tang Wee.

**Science is Everywhere** From the data they collected, Tang Wee and Yaw Kai are convinced that young children are really interested in science and it helps them in numeracy and English literacy.

Encouraged by the results, they hope to expand the project to include the Science Centre as a partner. The teachers are interested to continue to with the project, and the duo also wants to rope in parents so that the children’s science teaching and learning can continue at home.

“It will be like a full cycle,” says Tang Wee. “The kids will see that science is in their surroundings and everywhere. And science learning should involve the parents, the community, everyone!”

Tang Wee and Yaw Kai find that children are interested in Science at an early age.
Scientists in the Making

Principal Investigator Tan Lik Tong, National Institute of Education, Singapore
Co-Principal Investigators Subramaniam s/o Ramanathan, Goh Pi Lee Beverly, National Institute of Education, Singapore

RESEARCHERS ARE working with National Parks Board to observe the behaviour of *Perna viridis* (or green mussels) in various locations in Singapore. The data they collect will help us ascertain how polluted our environment is. The findings will also be presented at a symposium in NIE.

If you think these researchers are scientists or environmentalists, think again! They are actually secondary school students involved in Dr Tan Lik Tong’s research project on project-based learning in Singapore.

Owing the Project For his study, the students get to work with scientists like himself through a structured and scaffolded programme for project work. They even use the tools that scientists use for research.

Instead of telling them what they should do, Lik Tong and his team first armed the students with basic knowledge about marine eco-toxicology, and worked with them to come up with their own research questions and experiments.

“The key point of this programme is that the students need to own the project,” Lik Tong says. This is so that they would gain confidence and interest in research. As a scientist who had judged several science competitions at the national level, he felt that students who pursued their own research ideas tend to know a lot more than those who assisted scientists with their experiments.

For a more authentic research experience, the researchers also partnered with National Parks Board so that the data students collected can be used by the agency. “I hope students will see the relevance, that this is not just a school project but has real implications on the environment we live in.”

Teachers on Board As part of the study, the research team also conducted a workshop for the teachers about the programme and their role as facilitators. “We want the teachers to come on board as well, to see how things are run,” explains Lik Tong. “It’s better that way as they will be aware of what’s happening. Once the programme is over, they can continue it on their own.”

The responses from the teachers have been encouraging for the team. “We have a few of them expressing interest in a sustainable engagement with us. They want to continue this as they see its usefulness within the school system.”

In fact, Lik Tong and his colleagues have plans to develop a toolkit that schools can use to implement this programme themselves. “If this programme works, then it’d be great because you can introduce any kind of topic, not just marine eco-toxicology, with it.”

Lik Tong’s hope is to bring the culture of research into Singapore schools and cultivate a spirit of inquiry in our youth.

“At the end of the day, we want to encourage students to go further, if this is what they are interested in. They might want to do further studies, or even a PhD eventually!”
International Science Education Conference 2014

NIE proudly co-hosted the International Science Education Conference 2014 with the Ministry of Education (MOE) this year. Based on the theme “Pushing the Boundaries: Investing in Our Future”, this conference questioned the boundaries that influence Science education in Singapore. The aim of the conference is to develop scientifically literate global citizens as well as to examine the relevance of Science education in meeting the demands and goals of the future.

Held from 25 to 27 November 2014, this event examined strands such as Professional Development and Teacher Education, Assessment and Evaluation, Science in Informal Settings, Science Teaching and Learning, Curriculum and Policy, New Media and Technologies, and Science Literacy and Nature of Science.

The conference included prominent and international keynote and invited speakers Professors Steve Alsop (York University, Canada), Justin Dillon (King’s College London, UK), Sibel Erduran (University of Limerick, Ireland), Vicente Talanquerusa (University of Arizona, USA), and Hsin-Kai Wu (National Taiwan Normal University, Taiwan).

Through this conference, the organizers hope that the exchange and in-depth discussion of progressive ideas will help challenge or even replace existing assumptions and boundaries that are limiting Science teaching and learning so that we better prepare learners for future uncertainty and challenges.

Redesigning Pedagogy Conference 2015

NIE will host the Redesigning Pedagogy International Conference 2015 from 2 to 4 June 2015. The theme of the conference is “Leaders, Values and Citizenship in 21st Century Education”.

The conference provides a global platform for practitioners, researchers, educational leaders and policymakers to interact, share international and leading-edge research and best practices across schools and cultures, and forge new and innovative directions for educational research and practice.

For 2015, conference delegates who are interested in values and citizenship education can also choose to attend the Arts, Humanities and Literature Conference 2015 or the 11th International CitizED Conference in addition to the main conference on Day 3.

The themes of the conferences are “Live(d) Experiences: Imagination, Wonder and Spaces of I/M/possibilities” and “Citizenship, Character and Values Education for the 21st Century” respectively.

The conference is inviting proposals to examine disciplinary ideas about leaders, values and citizenship in 21st century education. Submission of presentations from all disciplines are encouraged as the strands of the conference address the full spectrum of grade levels and academic subjects, with an overarching focus on educational leadership, values education and citizenship.

Early bird registration starts on 1 December 2014. Come and explore answers to important questions about 21st century education with other educators and researchers at this conference.
Is There an Israeli Pedagogy?

Presented by Adam Lefstein

What can we learn from education systems abroad? What can we learn from the unique circumstances of Israeli culture and education system? NIE staff benefitted from a seminar given by Dr. Adam Lefstein, who is a Senior Lecturer at the Ben-Gurion University of the Negev, Israel.

Dr. Lefstein conducted the first and only systematic study of primary school pedagogy in Israel by looking at 120 lessons in 2 schools. To yield meaningful findings, Dr. Lefstein coded his data by adapted the coding scheme developed by NIE’s research project, the Core Research Programme.

On 3 October 2014, Dr. Lefstein spoke about key characteristics of Israeli pedagogy, such as discourse norms, learning tasks, power relations, values education and gender. He engaged the audience with his comparison of Israeli and Singaporean classrooms. NIE’s Dr. Lee Yew Jin from the Natural Sciences and Science Education Academic Group was the discussant for this seminar.

The seminar is jointly organized by two OER research task forces: the International and Comparative Studies (ICS) Task Force and the System Studies in Pedagogies and Educational Outcomes Task Force.

The Problem of Intellectual Imperialism

Presented by Syed Farid Alatas

What is academic imperialism and how does it affect us? Dr. Syed Farid Alatas, who is the Sociology at the National University of Singapore (NUS) gave a seminar to the academic fraternity on 4 Nov 2014 on the issue.

In it, he discussed how academic imperialism can be a problem and provided avenues of solutions for us to tackle it. At the structural level, politicians, bureaucrats and administrators need to be aware of this problem and be willing to do something about it. At the intellectual level, scholars need to take more ownership to overcome academic imperialism. The intellectual activity of generating alternative discourses at several levels with a view towards creating an autonomous social science tradition is discussed in this presentation. NIE’s Professor S. Gopinathan was the discussant for the seminar.

Dr. Syed Farid Alatas is Associate Professor also headed the Department of Malay Studies at NUS from 2007 to 2013. Prior to joining NUS, he lectured at the University of Malaya in the Department of Southeast Asian Studies. His areas of interest are historical sociology, the sociology of social science, the sociology of religion, and intra- and inter-religious dialogue.

This seminar is jointly organized by the International and Comparative Studies (ICS) and Teacher Learning and Professional Development (TLPD) Task Forces at the Office of Education Research (OER).

More information about the research task forces is available at: http://www.nie.edu.sg/office-education-research/research-and-development-framework
Research Highlights

CONGRATULATIONS TO our colleagues whose research projects have been completed this year.

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The full list of projects is available on the NIE website (www.nie.edu.sg) under Research@NIE.

New Publications

Inquiry into the Singapore Science Classroom: Research and Practices

This book offers insights into the research and practices of science teaching and learning in the Singapore classroom, with particular attention on how they map on to science as inquiry. Edited by Drs Tan Aik-Ling, Poon Chew-Leng and Shirley S. L. Lim, it looks at Singapore’s science educational practices at all levels, detailing both successes and shortcomings.

This is the fifth volume of the Springer Education Innovation Series. The series is edited by Series Editors Professor Lee Wing On, Professor David Hung and Dr Teh Laik Woon, and administered by Executive Editor Dr Dennis Kwek.

More information about the series is available at: http://www.springer.com/series/10092

Achieving with Integrity: Towards Mindful Educational Change

From 3 to 7 March 2014, NIE welcomed its 10th CJ Koh Professor Dennis Shirley to Singapore for a week of fruitful sharing and exchange. Professor Shirley interacted with colleagues from the Ministry of Education, the National Institute of Education and various organizations. His public lecture was entitled “Toward Mindful Educational Change: The Quest for Achievement and Integrity” and his seminar was on “Convergence Pedagogy: The Challenge Ahead”. He also participated in a roundtable symposium on “Helping Every Learner Succeed: Perspectives from Research in Professional Learning Communities and the Learning Sciences”.

This sharing is documented in the CJ Koh Professorial Lecture Series. The series is edited by Associate Professor Low Ee Ling. They are available at the NIE website: http://www.nie.edu.sg/research-nie/research-publications/CJ-Koh-Professorial-Lecture-Series