Core 3 Research Programme: Baseline Investigation of Science Pedagogy

By *Dennis Kwek*

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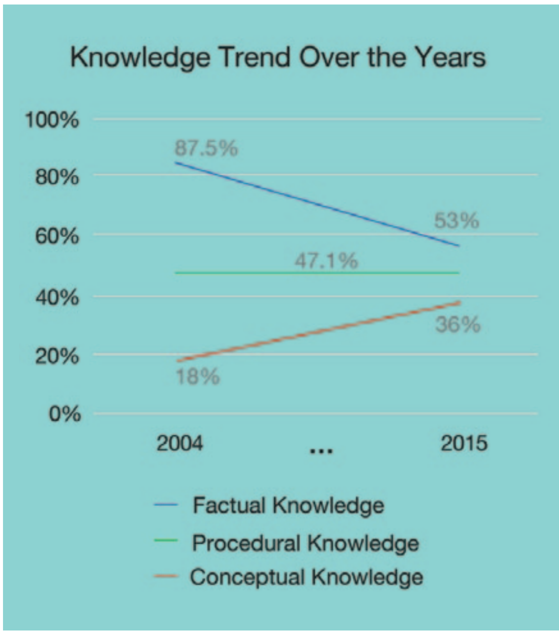
Since independence in 1965, the emphasis on Science in Singapore has been unwavering. It has helped to build our rapidly expanding and changing economy—from engineering and computing to new scientific areas such as biosciences, environmental and energy sciences, to name a few. Our Prime Minister, at the opening of the Singapore University of Technology and Design in 2015, has re-emphasised that STEM (Science, Technology, Engineering and Math) skills will remain crucial to Singapore for the next 50 years (Lee, 2015). This is further cemented by the recommendations of the Committee on the Future Economy where the high demand areas for the future economy include data analytics, cybersecurity, data sciences, robotics, life sciences and artificial intelligence. There is therefore a strong need to create a cadre of STEM and information communication technology (ICT) professionals, and subsequently, a need to prepare our children in schools to be ready for a science-rich future with bountiful opportunities for them to embark on science-related careers.

This has to be seen in the broader contexts of the aims of science education. Osborne and Hennessey (2003, p.2, 11–14) point to four key purposes: 1) utilitarian (practical utility of science); 2) economic (for sustaining the economy); 3) cultural (recognising the scientific achievements of humans); and 4) democratic (participating in and debating on key political and moral dilemmas which are inherently scientific in nature, such as climate change).

In Singapore, the Core Research Programme—of which we are now at the third iteration (Core 3)—has been centrally focused on the questions of "How do teachers teach?" and "Why do they teach the way they do?". The clear methodological focus and design philosophy of Core 3 is on "everyday classroom pedagogy, on the intellectual and discourse work of teachers and students in the classrooms" (Luke, Freebody, & Shun, 2005, p.9). We began to collect data on Science pedagogy in 2004, at the cusp of *Thinking Schools, Learning Nation* and *Teach Less, Learn More* reform initiatives. We collected data on Science pedagogy again in 2015.



We sampled a number of mainstream schools and teachers in average classrooms—1 teacher per school with a total of 10 schools—and collected 90 lessons in Primary 5 (P5) and Secondary 3 (S3) (Physics). We segmented the lessons into 5-minute phases and coded them for key pedagogical practices that we believe should be happening in classrooms, drawing from both the local curriculum intentions and international understandings of what science teaching and learning should be about. Interviews with teachers and students were also conducted.

In terms of Knowledge Focus, or what the knowledge emphasis is during that part of a lesson, we saw an emphasis on the following as shown in Table 1 on the left.

The chart above shows the trend of knowledge focus between 2004 and 2015. This can be attributed to the science curriculum reforms as well as an increased emphasis on scientific inquiry. The results are broadly comparable to the Singapore PISA 2015 findings, where Singapore Science shows a stronger emphasis on procedural and epistemic knowledge than content knowledge.

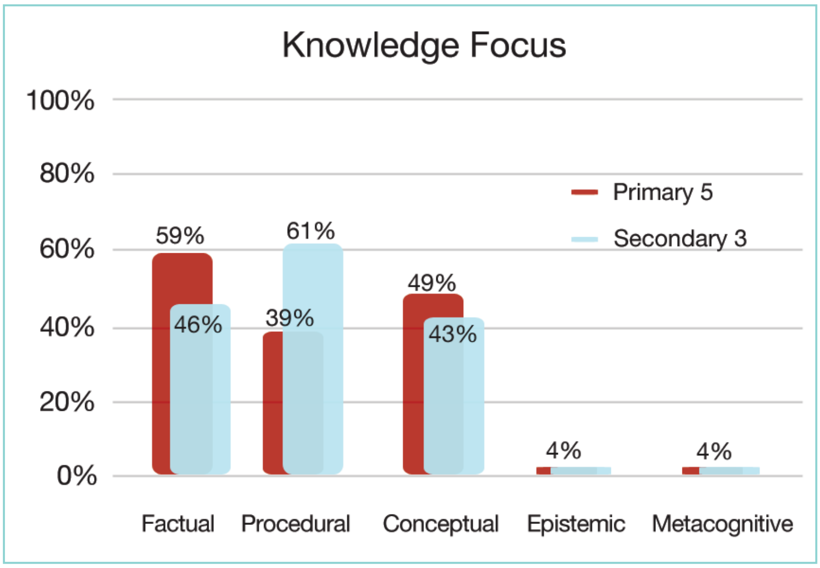
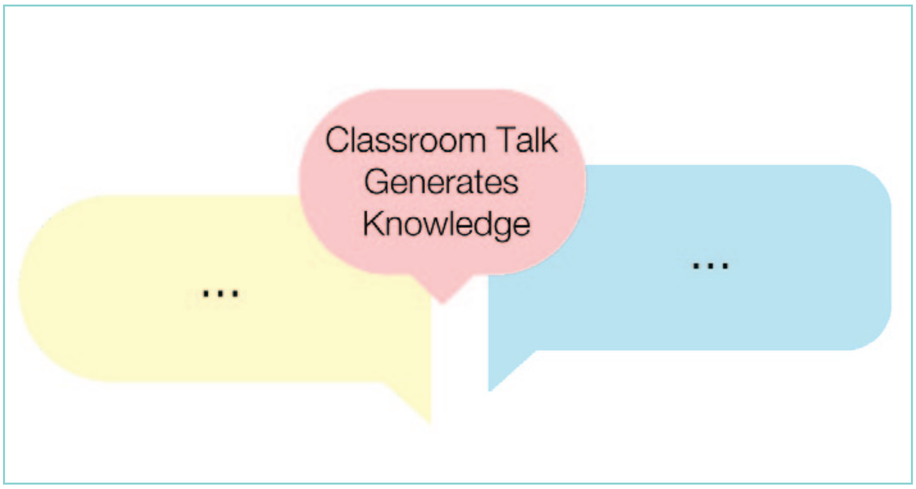


Table 1. Knowledge focus or emphasis during a lesson.



In terms of Epistemic Talk—the kinds of knowledge that is generated or discussed through talk—we see respectable proportions as shown in Table 2 below.

As such, there is definitely more room for Epistemic Virtues Talk in the classroom, where the talk focuses on the nature of science, justifying and arguing for scientific claims. Likewise, an average of 86 per cent of all phases in P5 and S3 had closed-ended questions with students required to respond with the correct answers, and 25 per cent with open-ended questions with multiple answers.

Such a proportion of closed-/open-ended question types is typical of Singapore classrooms. Based on our interviews with teachers, a key reason for this is time constraint—engaging in open-ended questioning requires time for active and engaging discussions, which comes into tension with the need to cover the necessary content students need to sit for examinations. A key strength of Singapore Science Pedagogy, we feel, is this balanced focus on factual, procedural and conceptual knowledge as teachers introduce and engage students in scientific concepts and procedures, while there is scope for improvement in increasing the focus on Epistemic and Metacognitive Knowledge.

In terms of the scientific skills that are exemplified in the Science syllabus, we find that observation, communicating in scientific terms, analysing patterns, compare and contrast, and inference to be respectable in P5 and S3 classrooms. However, we did not see a strong emphasis on skills such as evaluating reasonableness, accuracy and quality of information, predicting outcomes, generating possibilities, classifying objects of events, or formulating hypotheses. These latter skills are important scientific literacy skills, and areas that more innovations could be mounted on to help teachers improve the use of such skills in classrooms.

We also coded for when teachers explicitly mention or encourage students to embody scientific virtues such as curiosity, creativity, integrity, open-mindedness, perseverance and responsibility. In the 90 lessons we observed, we rarely saw or heard teachers talking about such virtues in the classrooms. Bearing in mind the caveats—these 90 lessons were observed during a specific time of the P5/S3 year, with only 10 teachers in mainstream schools teaching average P5/S3 Express classrooms. Most importantly, we also made the decision to only code when teachers explicitly mention or encourage such virtues. The rarity of encouraging such virtues through talk suggests an important area for improvement, especially given the significance of such scientific virtues. We also note that P5 and S3 students tend to engage in investigation far more than other scientific processes such as decision-making or creative problem-solving.

In terms of scientific inquiry, using the 5E model of inquiry, we observe largely teacher-directed inquiry rather than student-directed inquiry. Teachers tend to pose questions, provide materials, direct students to collect data, guide students in formulating explanations, provide possible knowledge connections, and give students steps and procedures for communication. We see strong emphasis on Engagement in Scientifically Oriented Questions, Evidence Management, and less for Explanation, Formulation, Elaboration and Evaluation. These findings again suggest that there is room for scientific classroom-based innovations on building capacities and opportunities for a more balanced and student-directed 5E inquiry pedagogy.

From our 2015 baseline study on Science P5/S3 Pedagogy, a number of recommendations can therefore be made as shown in the table on the following page.

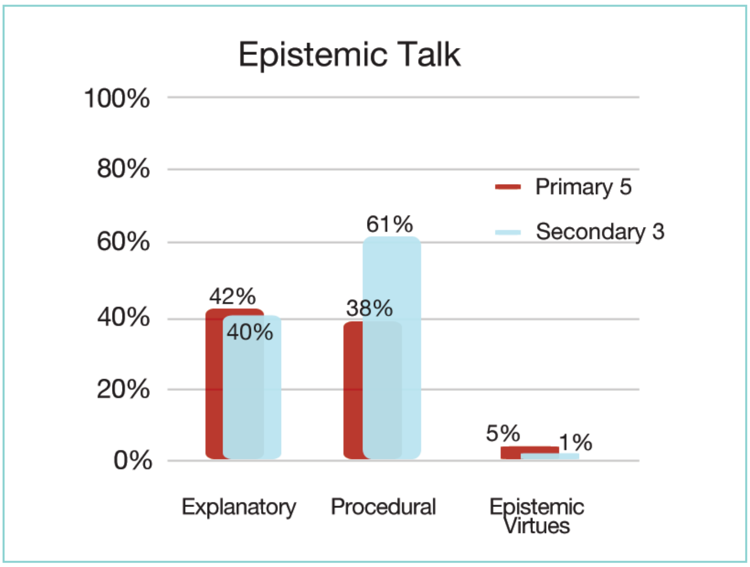


Table 2. Proportions of epistemic talk during a lesson.

Recommendations for a More Balanced and Student-Directed 5E Inquiry Pedagogy

- Create more opportunities for student agency in conducting their own investigations.
- Teachers to emphasise more explicitly in classrooms the importance of scientific virtues to students.
- Consider a more balanced approach to scientific inquiry.
- Emphasise more metacognitive and epistemic work in science classrooms.
- Consider the broader purposes of science education; consider how utilitarian, economic, cultural and democratic aspects can be translated into practices that will help students in their future.

Internationally, science education continues to emphasise the notion of science literacy. In a recent publication from the National Academies of Sciences, Engineering and Medicine in the USA, the authors argue for the need for teachers to engage in science literacy in classrooms: (a) Understanding scientific practices; (b) Content knowledge; and (c) Understanding science as a social process (Snow & Dibner, 2016). The notion of science as social process relates to the criteria of evaluating scientific expertise, the role of peer review, the accumulation of accepted findings, the existence of venues for discussion and critique, the nature of funding and conflicts of interest. The presence of websites such as Retraction Watch, which monitors scientific journal retractions due to irregular scientific methods, findings, replication issues, scientific misconduct (www.retractionwatch.com), signals a scientific world where science-literate citizens need to understand not only the content or nature of science, but also the social processes by which scientific knowledges are generated, shared, debated, refuted and retracted. Our students need to be prepared for such a future. As such, the work of science literacy, broadly envisaged by the National Academies, is perhaps one step towards that democratic purpose of science education.

References

Lee, P. (2015, May 8). Science, technology, engineering and math skills crucial to Singapore for next 50 years: PM Lee. *The Straits Times.* Available from: http://www.straitstimes.com/singapore/education/science-technology-engineering-math-skills-crucial-to-singapore-for-next-50

Luke, A., Freebody, P., Shun, L., & Gopinathan, S. (2005). Towards research-based innovation and reform: Singapore schooling in transition. *Asia Pacific Journal of Education, 25*(1), 5–28.

Osbourne, J., & Hennessey, S. (2003). *Literature review in science education and the role of ICT: Promise, problems and future directions.* Bristol: Futurelab.

Snow, C. E., & Dibner, K. A. (2016). *Science literacy: Concepts, contexts, and consequences.* Washington, DC: National Academies Press.

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