"A Racing Car Locked in a Garage": Education and Training of Science Teachers in Singapore

Yew-Jin Lee
National Institute of Education,
Nanyang Technological University
(Singapore)
yewjin.lee@nie.edu.sg

While student achievement has recently been shown to be very successful in international tests in Singapore, both qualitative and quantitative research has shown that classroom teaching here is still largely frontal, directed teaching albeit of a high quality and that students' epistemic practices are scarce. Longitudinal studies of a "model" secondary school that adopted inquiry science practices also showed that recent reforms did not significantly improve students' generation of new knowledge just as teaching was mainly confined to traditional methods [3]. Statistical modeling [2] has reported that the logic of teaching in East Asian contexts dictates high-efficiency content coverage in the face of high-stakes assessment regimes and societal expectations of success. The PISA 2012 report has even speculated that high content mastery by students has been a significant reason for their strong achievement in mathematics here that has compensated for fewer problem-solving skills.I claim that this situation is unsatisfactory; teachers in Singapore enjoy high levels of training in curriculum, leadership, and assessment strategies but development in the liberal education tradition appears to be lacking or unable to show itself in the classroom. This is a problem that demands a shift in thinking about what constitutes genuine learning and asks if politicians are serious about the rhetoric of effective learning in the 21st century. As a science teacher-educator, I have been experimenting with practice-based teaching, which I will share during my presentation. These have included a program where preservice teachers mentor after-school inquiry investigations with groups of pupils over a school term. Here, teachers and pupils collaboratively engage in projects whereby there are often no known answers in the textbooks although the teachers explicitly act as facilitators. Such practice-based teaching that follows the US Fifth Dimension program [1] help close the theory-practice gaps and are a viable model also for PD. As well, I share similar work done using a Microbial Fuel Cell with secondary school students and their teachers. We have much theoretical support from the ideas put forth by many from Aristotle to Durkheim, Michael Young and Paul Ricoeur about the need for intertwining abstract and practical knowledge. It is my contention that teachers in Singapore are ultimately underperforming with regard to their potential similar to a powerful car that is imprisoned in a garage and that once education (rather than mere training) is given priority, education for the young can truly advance.

1.Introduction

Over the last decade, science education in Singapore has won a number of accolades, especially so with respect to international achievement tests such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS). At the same time, teachers here have been praised for their commitment and high quality of teaching. They enjoy ample professional development (PD) opportunities, which allow up to a hundred hours of paid training per year for every teacher [1]. Given the priority to provide for the best for the education of local youth, it is thus no wonder that the annual budget for the Ministry of Education is only second to that of defence.

While this situation would make international educators envious of Singapore, research has shown how teaching here is largely driven by assessment concerns and is very teacher-directed. Because of the presence of high-stakes examinations at grades 6, 10 and 12, teachers are highly sensitive to examination washback and thus rely heavily on the national syllabus to guide teaching [2]. Teacher-fronted teaching is usually the most effective strategy for content transmission in large-class settings and thus it is the mode of choice notwithstanding pockets of inquiry-based teaching [3]. Even in so-called schools that have been champions of novel teaching methods, a longitudinal study of one such institution revealed that not only were sustained or meaningful program outcomes unlikely to have been fully successful, its implementation also did not assist students achieve high levels of scientific/epistemic literacy [4]. The PISA 2012 report has even speculated that high content mastery by local students has compensated for lower problem-solving skills! I claim that this situation is unsatisfactory; Singaporean teachers enjoy high levels of training in curriculum, leadership, and assessment strategies but their development in the liberal education tradition appears to be lacking or unable to show itself in the classroom. This is a problem that demands a shift in thinking about what constitutes genuine teacher professionalism and asks if politicians are serious about the rhetoric of effective learning in the 21st century. At this point, I would like to suggest that practice-based teaching (PBT) can be a useful way for practitioners (preservice or practicing) to learn how to balance theory and practice in education [5].

2. Overall "mechanism" of action

How does PBT work? I define PBT as the intentional combination of abstract knowledge to articulate with actual practice in classrooms to develop teachers that are savvy and knowledgeable. Praxis and concrete changes such as improved student learning are the tangible outcomes as the philosopher Giles Deleuze claimed that practice are just relays of theory and theory are relays of practice. For preservice teachers, therefore, encountering theories in/of education might be the initial stimulus for reflection; institutions like universities are the best places for providing abstract, textbook knowledge that everyday or personal experience is inadequate to furnish. What follows next is for participants then to cross boundaries into the real world of classrooms to implement aspects of what they have earlier learned, to enact what they have heard, and also to realize first-hand any resistance or failure. These teachers later can return back for structured, guided reflection and further rounds of planning armed with fresh information and realistic insights. In this dialectical movement between abstract and practical knowledge, ideas and knowledge about teaching are likely to get refined in a positive feedback cycle. PBT differs from the familiar teaching practicum in that there is a more deliberate alternation of formal theory with practice and their subsequent reflection and so forth.

Why is meaningful comprehension of practice so dependent on the constant movements between the abstract and the practical? Many have suggested how these two broad conceptualizations of knowing are perennial themes including candidates such as theoretical-practical logics, modern-primitive thinking, intellectual-manual, formal-practical reasoning and so forth [6]. Nonetheless, one can readily trace such distinctions between different kinds of knowledge ranging from the intellectual virtues of Aristotle to Marx, Dewey, Heidegger, Habermas, and contemporary interpreters such as Bent Flyvbjerg. Educational sociologist Michael Young himself builds his own dualistic-like models based on Durkheim, Vygotsky, and above all, Bernstein. Even though Aristotle's phronesis (action oriented knowledge that is sensitive to context and considerations of use) is biased towards practical understanding, this has to grow through the knowledge of universals (from episteme that abstract scientific knowing exemplifies) thereby underscoring its inherently dialectical nature. We argue that PBT is one fruitful way to ensure that teachers have opportunities for articulating these forms of knowledge as they develop greater understandings of the profession [7]. Two examples of PBT in Singapore follow as support.

3. Example 1: preservice science teacher education to facilitate inquiry

In a course that I coordinate, preservice elementary teachers facilitate grade 3/4 kids in a 6-8 week-long project involving seed germination in nearby primary schools. The children are first given many different seeds that they then are instructed to grow as they think best and to observe carefully what happens. The following week, the teachers scaffold the kids in asking "researchable" questions based on their own puzzlement, interests or curiosity. The children are helped along the iterative process of scientific inquiry skills eg controlling variables, and links are made to the school science curriculum where possible. This has been sometimes more prescriptive or directed than I am comfortable with and is typical of the urge among teachers for maximum content coverage and getting a "successful product" as opposed to valuing the learning journey with dead-ends and false-starts. For this course, we used a science inquiry textbook available online over the weeks as I discussed abstract theories with the teachers: http://www.nap.edu/catalog.php?record_id=11882

Teacher-student ratios vary according to the school sites but are no larger than one teacher to three children. If there were some special challenges or problematic investigations, children were given personal help. Over the weeks, kids bring their mini-experiments for show-and-tell in their small groups, and the teachers scaffold them, at least I underscore working on the development of kids' ideas no matter how bizarre/naive they are initially. Journeying together is now an important side-benefit as teachers and children start from a position of not-knowing the answers that are often not found in textbooks. The children can draw, take pictures or write down their observations on big sheets of butcher paper so as to have a permanent record of their evolving explanations/ideas/results and to offer a visual map of future plans for investigations. Each after-school session lasts about 1.5

hours; not every child is present at all times and often experiments do not get conducted or the plants die. To speed things up, some teachers prepare templates or worksheets to guide learners in their thinking. At the end of the course, the children make group posters to present in a symposium and to celebrate their experiences of being a young scientist. Rather than front-loading concepts and theories that might not even be used, knowledge of teaching was now only appropriated just-in-time as teachers collaboratively facilitated the kids week by week to do inquiry science. When a problem arises, the teachers refer back to the textbook with fresh eyes to look for solutions just as we discussed together what were possible options for praxis. In this contrarian but highly effective manner, learning then becomes the by-product of activity (helping the kids do science) rather than its original motive [8]. This is a clear case of developing practitioners by interacting with theoretical knowledge of teaching and practical facilitation with actual students while in an university course on teaching methods.

Example 2: Inquiry science in schools through the MFC

When teachers facilitate unfamiliar student projects, they are also forced to interrogate their existing knowledge of teaching (inquiry) as they tentatively guide their learners. It is this PBT scenario that I introduce how my teachers used the Microbial Fuel Cell (MFC) in one research project [9]. Moreover, from the perspective of learners, the MFC itself is a dialectic of theoretical (scientific) and practical (engineering) knowledge. Basically, it is a fuel cell that produces a small voltage depending on the chemical reactants and biological organisms such as yeast. How to derive the highest voltage from this apparatus is unpredictable as there are multiple interacting variables and conditions hence this presents extremely interesting challenges for learners not to mention their mentors as all are working in the dark! Participants can thus learn good science and engineering/design principles as well as authentically explore alternative sources of energy with this relatively simple and safe apparatus. The MFC is exciting because it is an agentic (people set their own goals of activity) process of learning that affords a tangible means to evaluate shared progress—students can see how close they are to a working or functional prototype. We like to think that helping teachers facilitate learning here elegantly consolidates practical activities with the occasional dead-ends and uncertainties that scientists encounter in a classroom context *plus* the accompanying deep intellectual reasoning activities that is often “on the back burner” when teachers say that they are doing inquiry. Again, rather than students (and teachers) using a tool <u>in order to</u> learn science or learn some concepts <u>prior to</u> applying a technology, these processes are intertwined with the MFC. In this extended “doing with understanding” process of authentic problem solving, [10] further proposed other important design principles such as learning appropriate goals (in science), having scaffolds that support both student and teacher learning, frequent opportunities for formative self-assessment and revision, and social structures that support and promote participation and agency.

Conclusion

It is my contention that teachers in Singapore are ultimately underperforming with regard to their potential similar to a powerful car that is imprisoned in a garage and that once education (rather than mere training) is given priority, education for the young can truly advance. I have suggested that practice-based teaching can perhaps help teacher regain some of their professionalism, knowledge, and agency through consciously articulating theory and practice. In this philosophically sound manner that many others have also described, science teachers can help their students as well as themselves live out a richer and more complex form of scientific literacy that is so urgently needed now.

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