Chapter 7
Commentary: Developments and Reforms in Science Education for Improving the Quality of Teaching and Research

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7.1 Introduction

Reviewing colleagues' work and providing a review, a commentary, or reflections is always a privilege because it enables the reader to be more aware of his or her own research contributions. The reader may provide critical and constructive comments as in the case of a journal manuscript submitted for consideration or as in the case of this chapter to reflect how the reading relates to the reviewers' knowledge and experiences and then comment. In this chapter, we comment on some aspects—it is not possible to comment on all—and reflect upon the chapter authors' work from Mainland China, Lebanon, Macau, Malaysia, and Mongolia about science education research (SER) and practice in their countries/regions.

These five chapters are written with slightly different themes as a review, an overview, or a history of the science education in the countries/regions concerned but each chapter is comprehensive and informative allowing readers to have a good understanding of the status of science education there in one way or the other. After reading through these chapters, we provide comments and attempt to critically scrutinize the science education in these countries from international perspectives with the intents of highlighting some areas that other countries/regions could emulate. We also comment on other areas that are gaps in the research that could shape future directions for improvement. There are indeed common social, political, and educational problems and challenges facing these four countries and Macau, China's Special Administrative Region (SAR). Apart from discussing each chapter, we make comments based on the relevant literature, our personal and/or research experiences associated with the science education in each chapter and/or our collaborative work with the authors concerned.

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7.2 Mainland China: Internationalization of Science Education Research and Practices and Some Constraints

The current status of SER in Mainland China (hereinafter, simply "China") as reviewed in Chap. 2 by Wang et al. appears to be an important part of the book not just because that one fifth of humanity in the world are living in China, also because of the increasingly influential impart of China—the world's second-largest economy—on global climate changes, environmental pollution, biodiversity, food safety, health issues, and so forth, most of which are related to science education.

Wang et al.'s review of SER in China is both comprehensive and informative about three major science domains on six aspects: curriculum and textbooks, teaching, learning, teachers' professional development, scientific inquiry, and learning progressions and students' domain-specific cognitive development. As the authors conclude, SER in China is subject-wise so that educational research is reviewed separately in the three major science subjects: physics, chemistry, and biology, and claimed that "all have had fruitful achievements in all the six aspects above" (p. xx). The various research studies showed that these studies were underpinned by the common theoretical frameworks or models in international SER (e.g., NOS, BSCS course, 5E learning, constructivism etc.) and some were also part of the ongoing projects in other countries (e.g., WISE, TELS etc.), as well as being conducted using common quantitative and qualitative methodologies, including the latest Rasch model method and the popular semistructured interview method.

Here we attempt to comment on a few aspects from international perspectives. First, for the aspect of learning, conceptual change learning—the dominant research agenda for learning science since the 1970s (Amin et al. 2014)—is also a focus in the review of studies on learning including some comparative studies with other countries and with Taiwan. From the perspective of multi-dimensional conceptual change in learning science (see Duit et al. 2013; Tyson et al. 1997), we believe that the major focus in science education in China is on the epistemological dimension, and that teaching and learning of science is more or less teacher-centered and examination-oriented compared to many other countries. Indeed, China has sought to learn from the American-style flexibility in schooling, for example, less lectures, less drills or memorization but more discussion and student-led activities (Cavanagh 2007). More improvement in this regard has since been done, as reported in Chap. 2.

Second, for the aspect of the research on curriculum areas of science education, environmental education is not mentioned, whereas it is discussed in the chapters on Lebanon, Malaysia, and Mongolia, which like Chap. 2 on China, also provide an overview of SER in their respective countries. Environmental education is increasingly important in international SER—especially in countries with extensive industrialization and urbanization—and therefore, could be a focus of science education in China where some of the most urgent reported science-related problems include environmental pollution and food safety. China is currently undergoing more changes while it is striving to become a world economic power alongside the USA. Meanwhile, people in China are developing more public awareness of the environmental issues and citizens' rights vis-à-vis the vested interests of private and state-led capitalists, for example, Chinese officials halted construction of a p-xylene (PX) factory in Shifang city in 2012 after violent protests from residents (BBC 2012). As is well known, there are always tensions of this kind in both developed and developing countries; earlier this year while China championed the importance of environmental protection, it blocked web access to an online popular documentary on air pollution in China (Wong 2015).

Third, another area worthy of our comments is about the research on nature of science (NOS) reported in Chap. 2 in studies on four aspects including teachers' professional development. However, the authors and readers may also be interested in the work of Hong Kong colleagues (Wan et al. 2011, 2013) who found that when Chinese science educators were compared to those of the Western countries in their NOS values, "[t]he most prominent difference is the absence of the democratic argument" (Wan et al. 2011, p. 1118). More notable is Wan et al.'s (2013) study and discussion of the impact of Marxist thinking on how China's science educators taught NOS to prospective science teachers. This hidden ideological factor affecting teaching and teacher education in modern China and its implications on research and practice has received no mention in the research literature, not even in Lederman and Abell's (2014) latest handbook on SER. Science education researchers may recall that Lysenkoism of the pseudoscientist Lysenko[1] in the former Soviet Union was once embraced by China under Mao Zedong—for agricultural developments—but was soon discarded as fraudulent pseudoscience after Mao had died and reforms in China started in the late 1970s (Dikötter 2010; Schneider 1989). Those events conjure up the second author's memories of his personal experience of learning the Soviet-style school science as a primary school student in China during the late 1950s.

Many changes and innovations in science education practice and research—"to improve Chinese citizens' scientific literacy, build up human resources, enhance the country's capacity for independent innovation, and realize the great rejuvenation of the Chinese nation" (p. xx)—have been taking place since China's eighth curriculum reform started in 2001. Indeed, China has since produced many talented scientists and engineers for the needs of the country's development. Wang et al. have pointed out in their concluding remarks that:

> the internationalization of SER in Mainland China is not enough, especially in publishing studies in international journals. How to bring the native [local] studies to overseas and how to get recognition of international peers are important tasks for the researchers in Mainland China. (p. xx).

We agree, and recognize this challenge applies to all authors of the chapters we reviewed and is especially difficult for nations new to international SER.

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[1]Trofim Denisovich Lysenko (1898–1976) was a protégé of Stalin; his Lysenkoism "denied the validity of classical genetics from Mendel to Morgan and promoted its own theory of heredity based on the belief that acquired characters can be inherited" (Schneider 1989, p. 45).

On the whole, Wang et al.'s chapter has analyzed a huge collection of SER studies in China and presented readers with a *big picture* of how research has been translated into practice, as well as their implications and future directions. We look forward to seeing SER and practice in China continue its path toward internationalization despite some constraints.

7.3 Lebanon: Science Teaching and Learning as Inquiry in Students' Mother Tongue or in a Lingua Franca of Science

At NARST 2001, the first author of this chapter was part of a symposium involving colleagues from Lebanon, the USA, Israel, Venezuela, Taiwan, and Australia that examined the role of inquiry in science education. All presenters learned about the status of inquiry teaching and learning in their own and the other countries/regions, the essential issues of which were published in *Science Education* (Abd-El-Khalick et al. 2004). In his country contribution to this article, Saouma BouJaoude (Chap. 3 's first author) explained how, in a then new Ministry-designed and developed curriculum, inquiry teaching was being implemented at the pre-college level. He commented that while much of the curriculum is well intended for inquiry in the classrooms, anecdotal evidence showed that most science teaching tended to be traditional. "The curricular emphasis on inquiry, while necessary, is not sufficient for the fruitful implementation of inquiry approaches to the teaching and learning of science in Lebanon" (p. 401). BouJaoude also noted that there was a mismatch between the proposed teaching approach and the high stakes assessment system that is part of Lebanese education.

In Chap. 3, among the identified four challenges facing schools, BouJaoude and El-Hage refer to inquiry as the second challenge "equipping schools with the necessary material, laboratory and ICT equipment to provide students with the opportunity to participate in minds-on and hands-on inquiry science" (p. xx). Like many school systems, inquiry learning is seen as an important and worthwhile outcome though this goal is often not achieved for two reasons: the need for adequate professional development opportunities for teachers and the need for examinations to match the teaching goals, continue to be two important educational challenges in Lebanon identified by BouJaoude and El-Hage. In reviewing research by Lebanese authors over a 15-year period, these authors reported a continued emphasis on qualitative methods, a trend to understand the status of science education in Arab states, and emerging theoretical frameworks using French SER traditions.

When we read the ranking of countries based on TIMSS or PISA scores, unless one knows the school system and the history of the country, especially in recent times, one has no idea about the language of instruction. We learn from Chap. 3 that the language of instruction in science is English or French whereas the students' mother tongue is Arabic and that students do not have strong language skills in English or French. We wonder how many other countries also face this situation and hence their students might have lower scores on TIMMS and PISA than might have been the case if the language of science instruction were the students' mother tongue. This reminds the first author of this chapter about a visit to the University of San Carlos in Cebu, the Philippines, where Dr. Malou Gallos was a faculty member, following her successful doctoral studies at Curtin University (see Gallos et al. 2005). The first author wanted to see firsthand the teaching of an adapted lecture style involving an instructional cycle of three phases: a plenary or mini-lecture, seatwork activity, and a summary or closure. The language of instruction was English. The first author also interviewed students about their experiences and almost incidentally asked them when they used English and Cebuano, their mother tongue. Almost all students stated that they stopped speaking English as soon as they left the classroom or lecture. Here is an issue of teaching and learning science that deserves more attention—the language of instruction as opposed to the mother tongue in international assessments. Chapter 3 on Lebanon also comments that many teachers in Lebanon "lack foreign language skills that influence the quality of their teaching because the language of science is English or French" (p. xx). We shall see in Chap. 4 on Macau (a former Portuguese colony) and Chap. 5 on Malaysia (a former British colony) that the language of instruction in science is also an issue that affects the quality of science education. The issue using non-mother tongue language of instruction also reminded the second author of his many years teaching biology and science in Hong Kong (a former British colony) and a case study on Cantonese-speaking students in Hong Kong learning genetics in English (see Tsui and Treagust 2013).

7.4 Macau: Encouraging Efforts to Improve Science Education Research and Practice

In Chap. 4, Wei reports on a region-wide SER study in Macau, an SAR of China. Macau's schools, mostly private, enjoy autonomy in their own way of teaching and learning. The study followed a common mixed-methods research design using questionnaire surveys, classroom observations, semistructured interviews, case study, and document analyses to collect data from multiple sources. Both the quantitative and qualitative data can then be analyzed, compared, or triangulated to increase the research rigor and to yield results with better reliability and validity. For a small region with only 46 secondary schools, this study design serves well to explore the various aspects of science education in the region: school-based science curriculum, science textbooks and their uses, science teaching methods, science learning environments, and students' attitudes to science and school science. The analyses and interpretations of the rich corpus of data in the region-wide study appear to yield meaningful findings that should have important implications for improving science education in Macau in one way or another and to solve the problems and meet the challenges concerned. One of the aims of the study was to find out if the features of current teaching and learning were associated with students' development of scientific literacy. Indeed, the PISA 2006 results showed that the 15-year-old students in Macau performed above the OECD average and that they internationally ranked between 15 and 20 on the combined science scales.

However, the issue of the language of instruction raised in Chap. 3 on Lebanon and Chap. 5 on Malaysia could also be one that warrants investigation in Macau. Wei notes that there are both Chinese-speaking and English-speaking schools in Macau where, we assume, that the medium of instruction (MOI), as it is called in Macau and Hong Kong, is Chinese in the former type of schools and English in the latter type. For those schools which use English as the MOI, the students and teachers are likely to face the same problems and challenges as those in Lebanon where Arabic-speaking students/teachers are using either English or French as the MOI or those in Malaysia where different ethnic groups with different mother tongues are using Bahasa Malaysia or English as their MOI in learning science.

Macau, one of the two SARs of China (Hong Kong is another one), was a former Portuguese colony, which was returned to China in 1999 and is maintaining its capitalist system under the policy of "one-country-two-system" of the Basic Law[2] for 50 years. As Wei points out, because of the need of schools to prepare for many students to further their studies in China, textbooks are mostly from Mainland China. This may also create some tensions due to the differences of two educational systems in China and in Macau and the teachers' thinking and beliefs. An emerging challenge in science education in Macau could be about how to strike a balance between, and to resolve the possible tensions arising from, the differences of the local (capitalist) and the national (socialist[3]) science contents and contexts.

7.5 Malaysia: Challenges with Curriculum Reform and Changing the Language of Instruction

The first author's initial experience of the education system of Malaysia was through his work as a consultant to academic staff at the Regional Education Centre for Science and Mathematics Education (RECSAM) administered by the Southeast Asia Ministers of Education Organization (SEAMEO) in Penang, Malaysia. At this Centre, courses are offered to science and mathematics teachers in the 11 SEAMEO Member Countries, including Brunei, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. In addition to teaching courses on teaching methods and how to conduct research projects, the first author conducted research

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[2]http://www.umac.mo/basiclaw/english/main.html.

[3]Or "socialism with Chinese characteristics" as the political system under the Communist Party of China's one-party rule (see recent official news from China at http://news.xinhuanet.com/english/china/2013-01/05/c_132082389.htm).

in local schools (see Liau and Treagust 1989) with multilingual colleagues. Through RECSAM, the first author met Dr. Molly Lee, then at the Universiti Sains Malaysia, and read her highly informative paper about science curriculum reforms in Malaysia (prior to 1992). Lee's (1992) review is in many ways similar to that of Nookoo's Chap. 6 which describes the periods of development of science education in Mongolia.

In Chap. 5 by Halim and Meerah, the first dozen pages describe these same developments of science education as reviewed by Lee, including the influence of British educational models like Nuffield and the Scottish Science Project, as well as the New Primary Science Curriculum and the New Integrated Secondary Science School Curriculum. Lee's article which was not cited also explained the rationale for some of these curriculum changes that came not only from Western countries but also from Islamic countries. In discussing the current status of science education in Malaysia, Halim, and Meerah present data about falling recruitment and interest in science and technological studies and careers; they offer reasons for these data that are similar to other countries where science enrolments are in decline—examination-oriented teaching, ineffective teaching of abstract concepts, and lack of practical and experimental activities.

An important issue addressed by Halim and Meerah is that of the language of instruction for science has changed from Bahasa Malaysia to English (in 2003) and back to Bahasa Malaysia (in 2012). One reason for the more recent change is the declining TIMSS assessment scores. As noted earlier, this situation about language of instruction is similar to that of Lebanon, Macau, and the Philippines. To address this language issue, recent research conducted in Malaysian schools (Damanhuri et al. 2016) used an instrument written in both English and Bahasa Malaysia.

An important aspect of Chap. 5, which has currency in many nations, is the need for the education system to produce graduates in science (and mathematics and technology) that meet future needs for employment possibilities and opportunities in these sectors. Malaysia has set a very high 60 % Science compared to 40 % Arts enrolments in upper secondary school. Halim and Meerah note that science enrolments are only about half the target percentage. The reasons for the issues described in Chap. 5 are supported in a recent report by Ibrahim (2015) from the Academy of Science Malaysia.

7.6 Mongolia: Challenges to Meet the Needs of Contemporary Society

Prior to 2008, the first author's knowledge of Mongolia learned through books or television was of the capital city, Ulaanbaatar, people on horseback with nomadic lifestyles and an open landscape like the outback of Australia. This knowledge changed in September 2008 when the first author attended the Celebration Colloquium at the University of Kiel's Leibniz Institute for Science and Mathematics Education (IPN) to honor Professor Dr Reinders Duit prior to his retirement. Professor Duit had been awarded an honorary doctorate from the University of Ulaanbaatar in recognition of his work during 2005–2008 in Mongolia to help develop physics instruction by supporting the work of Professor Burmaa Banzragch who also was a visiting scholar at the IPN.

It is very helpful for readers with little knowledge about the Mongolian educational systems to learn about these systems from Nookoo's Chap. 6 that chronicles the systems and their changes in four periods. Reading about Chap. 6, one has a clear conception of the curriculum changes from being highly structured and contextualized to one, from 2004, with new education standards where "schools and teachers were required to develop their own curricula under the open curriculum policy" (p. xx) with more attention to the abstractness of the science concepts and a more overall academic orientation. Such changes seem to us as being quite dramatic and as might be expected. Nookoo reports that there was "a lack of support for the implementation of the natural science educational standards and that teachers did not know how to implement student-centred teaching methods" (p. xx). We know that these issues are of international concern. As reported by Abd-El-Khalick et al. (2004), many countries reported similar issues. However, a recent European project, PROFILES[4] showed that student-centered teaching—in the case of inquiry learning—can be effective when teachers work directly with university-based academics. Some evidence of such cooperation in Mongolia is evident in Nookoo's chapter but, as in PROFILES, for the majority of teachers this kind of cooperation is not possible. Another challenge for science teachers implementing the new curriculum in Mongolia was that it had an outcomes-based approach—for knowledge, skills, uses, and evaluation—and to integrate content from different science domains. These goals are difficult to achieve even in more mature educational systems, especially when "the approaches used for assessment were not reformed" (p. xx). Nevertheless, international cooperation with teams from New Zealand and Japan have been instrumental in ensuring that the changes put forth by the Ministry of Education and Sciences could be assessed and implemented.

Chapter 6 concludes by ensuring readers that two decades of change from the previous social order to a new society has resulted in tangible successes and new experiences and that "the critical threshold for educational reform has been crossed" (p. xx). In any reforms, the goal has been to "combine the best international standards/curricula and careful consideration of the domestic conditions and the existing knowledge base" (p. xx). Like many resource rich countries, Mongolia will need an increasing number of scientists and engineers, and as Nookoo writes, there will be an increased demand for natural science education and the efforts to date will hopefully see the reforms come to fruition. However, for bringing about successful changes in the science curriculum in Mongolia, there are still problems in science teaching and learning which are likely fruitful agendas of research for further reforms.

[4]http://www.profiles-project.eu.

7.7 Coda

We hope that SER as reported in the previous five chapters can translate into practice and make contributions to create a more peaceful and prosperous world with "a more scientifically literate citizenry, a more ecologically balanced global environment, and a more socially just and democratic global community" (Treagust and Tsui 2013, p. 364). We suggest readers to think about the challenges and issues concerned and seek some further readings.

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