Chapter 12
Commentary: What We Can Learn from Science Education in Asian Countries?

Opportunities and Challenges For: Perspectives Based on the Experience

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This book section consists of descriptions of science education research and practices in four different Asian countries: Singapore, Taiwan, Omen, and Thailand. Although the current state, the opportunities, and the challenges each country face are different, there are several commonalities and shared interests. Therefore, it will be valuable to learn and collect ideas from these example countries. This commentary aims to make a summary of each chapter and then conclude based on these summaries.

12.1 Science Education in Singapore

Singapore is a small city–country without natural resources. Therefore, Singapore has always focused on education and the progress of the students and whole country in order to meet the challenges of twenty-first century. Singapore has also been successful in the implementation of the policy and students have performed well in International comparative studies since 1990s.

Professors Kim Chwee Daniel Tan from the National Institute of Education, Tang Wee Teo from the Nanyang Technological University, and Chew-Leng Poon from the Singapore Ministry of Education analyze history, present, and future of science education and science education research in the context of Singapore. For example, the period 1959–1978 was called a survival-driven phase with a focus on "the development of a literate and technically trained workforce." Since late 1970, Singapore has emphasized English, mathematics, science and technical education in order to educate competent people who are able to meet a rapid globalization and

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knowledge-based economy. Late 1990 have been called as the ability-driven phase. The fourth and current phase is student-centric, values-driven phase and it was launched in 2011 with the aim to focus on the holistic development of the child "centred on values and character development."

In addition to historical analysis, the authors analyze in a versatile way national level science education policy and implementation of this policy through national science curriculum, assessment traditions, and the use of versatile teaching methods, including use of ICT, and, moreover, through the selection of core content from the primary to high school levels. The curriculum emphasizes science learning as an inquiry process and focusses on the knowledge, skills and processes, ethics and attitudes required in the practice of science, as well as the understanding of the impact of science in daily life, society, and the environment. The authors analyze in depth the implementation of science curriculum from primary to upper secondary level and use in this analysis outcomes of science education research from Singapore.

12.2 Thai Science Education Progress Through Crisis to Opportunities

Assistant professors Dr. Chatree Faikhamta from Kasetsart University and Dr. LuechaLadachart from the Thai Ministry of Education analyze Thai science education progress through crisis to opportunities. In the beginning of this chapter, the authors introduce (1) national-level education policy topics and its influence to globalization and "westernization." (2) Second, authors provide a synopsis of the status of the current educational context, including the aims of science education, student performance, and teacher preparation and development. Third, the authors offer a brief overview of the (3) science education reforms that have occurred in Thailand since 1868 and, moreover, (4) reflect on these reforms based on empirical research and on their personal views as Thai science educators.

The authors argue that science is one of the core subjects in the curriculum because science and technology skills are needed in the development of high-technology and information-based industries. The form of the curriculum support teachers to plan their teaching according to the description of learning outcomes as well as to assess the outcomes. The national curriculum state that all learners should become scientifically literate or use their science knowledge and thinking in different contexts. The curriculum emphasizes inquiry-based science teaching and learning the nature of science as a part of the literature. However, the authors argue that curriculum and school practice focus just on learning of inquiry skills rather than understanding the nature of science.

The analysis of student performance shows that despite the serious improvement of science education in Thailand, students' performance has not significantly improved. Thai science education research explains this by "traditional" teaching practices which have not developed although science teachers have been encouraged to shift their “traditional” teaching style. This research has shown that classroom events are more complex and teachers are less able to use the new ideas than what has been expected. Another outcome of the research on teachers’ beliefs and practices is that although teachers are aiming to support students to understand the nature of science they are emphasizing the learning of science process skills or inquiry skills. Teachers believe that the students can instinctively learn scientific process skills, scientific thinking, scientific methods, and the attributes of scientists when carrying out experiments.

In the end of this chapter, the authors suggest recommendations to the policy and the practice level. First, at the policy level, the politicians change policy and science curriculum frequently and this makes it difficult to adopt new ideas at classroom level. Therefore, the policy makers and curriculum developers should rethink common long-term and sustainable goals for science education at the national level. Second, science education standards should clearly address inquiry orientation and explain how to apply it in science classrooms ion practice. Third, effective science teacher education preparation programs are needed in order to guarantee solid knowledge base, especially pedagogical content knowledge, and reflection skills for science teachers. However, science teachers might benefit on life-long learning skills which are needed in changing the working life. In many countries, research orientation as a part of the program is aiming to support this type of life-long learning skills.

12.3 Opportunities, Trends, and Challenges of the Science Education in Oman

Dr. Al-Balushi from the Sultan Qaboos University analyzes opportunities, trends, and challenges of science education and science education research in Oman. The author introduces the Oman educational context, where education system and science education are a part of it and the short history in science education research. An important reform in Oman educational system was the establishment of the Basic Education system in 1998. An emphasis in this reform was given to science, mathematics, foreign languages, technological, and life skills.

New national level science curriculum emphasizes inquiry-based and student-centered, education which supports learning of life skills, critical thinking, and the ability to understand and apply scientific and technological knowledge. Moreover, the curriculum emphasizes the use of modern educational technology and problem solving strategies. However, the authors argue based on the current research that teaching practice in science classrooms does not reflect the aims of science education and traditional teacher-centered methods that are still dominant in science education.

In general, research is understood as a tool for growth and productivity of society and economy in Oman. The research in science education has improved in 2000 because of the establishment of the first postgraduate program for science education research at Sultan Qaboos University (SQU). Moreover, funding for science education research was started to allocate by the Research Council (TRC). The author of the chapter gives interesting examples of science education research. The outcomes of this research have been published also in international journals. For example, the author introduces the research on teaching and assessment practices in Oman, outcomes of international comparative studies, research on sociocultural factors related to learning and research on teachers' beliefs and on students' common misconceptions in biology, chemistry, and physics. There are several examples of research in international level. One example is the research on visualization. The studies focus on: (1) learners' imagination of different submicroscopic scientific entities, and its relationship with their spatial ability; (2) their evaluation of the credibility of different scientific models, and its relationship with their spatial ability; (3) their visualization of different macroscopic and microscopic dynamic interactions; and (4) the presence of anthropomorphism and animism in learners' mental images in science. Finally, the authors introduce an interesting research on trends of science education research in Oman.

However, there are a number of challenges in education research in Oman. The main one is the limited number of science education researchers in the country. Especially, the number of female researchers is very low. The number of quantitative research studies is low compared to qualitative research and, moreover, there is limited attention to sociocultural issues. The author proposes that some of the pitfalls and challenges could be resolved by establishing a national science education research center that coordinates the research efforts and directs them toward the most pressing issues related to science teaching and learning. In addition, providing more scholarships to science education researchers to complete their Ph. Ds and founding a national professional science education research association could help in increasing the number of science education researchers and foster the research activities in the country.

The authors present a kind of consensus interpretation of the chemistry didactics in Russia and argue that the following domains of knowledge form the core of the chemistry didactics:

- general development of science,
- curricula for chemistry,
- allocation of chemistry lesson hours to grades (when and how much),
- learning materials for chemistry: textbooks, problem books, etc.
- journals, periodicals, conferences, and meetings for discussing didactical and pedagogical,
- collaboration and interaction between administration, teachers, and researchers,
- chemistry education research society for discussing on (research-based) improvement of chemistry education,
- pre-service and in-service teacher training,
- research in didactics of chemistry.

12.4 Opportunities and Challenges for Science Education in Asia: Perspectives Based on the Taiwan Experience

The Taiwanese professors Chorng-Jee Guo from the National Changhua University of Education and Mei-Hung Chiu from the National Taiwan Normal University analyze opportunities and challenges for science education in Taiwan and in Asia from the point of view of the experiences in Taiwan. These experiences have been published recently in an edited book by Chiu (2016). This book reports the successes and the achievements and, moreover, examines the existing and emerging opportunities and challenges for science education in Taiwan. The book consists of 22 chapters in which the international author team analyze and contrast wide range of topics on science education research and practice in Taiwan and all over the world.

The book chapter starts with an introduction to science education in Taiwan through four sub-chapters. The first chapter introduces a historical review of research projects on science education funded by the National Science Council. The second chapter analyzes the trends in science education research in Taiwan through a content analysis of the *Chinese Journal of Science Education* from 1993 to 2012, the next chapter is a commentary on the first two chapters by Reinders Duit, and finally the last chapter focus on the people and events shaping science education in Taiwan from an international perspective. In general, the sub-chapters offer very positive picture about the progress and development of science education and research in Taiwan.

Several research projects funded by the Department of Science Education (DSE) at the National Science Council (NSC) since 1980s have had a solid link to the science classrooms and raised the quality of science education research and, moreover, have had a general impact to K-12 science teaching and learning. The authors of the chapter introduced several key areas of research, like research on conceptual change and research on students' misconceptions; research on conceptual learning and learning of process skills and assessment of learning, including secondary analysis of the data of international comparative studies; research on scientific argumentation and socioscientific issues; research on use of educational technology in classroom and in distance learning and; moreover; research on teacher education. In addition to traditional qualitative and quantitative research methods, science education scholars in Taiwan have integrated new research methodologies, such as neuroscience methods, eye tracking, and FaceReader, in order to capture a deep picture of science learning and engagement. Because of solid funding, competent researchers and versatile research methodologies, there has been a rapid increase in the number of papers from Taiwan appearing in international high-quality journals. Between the years 1993 and 2012, an average of 3.7 % of the publications in the five top journals was from Taiwanese researchers. This is a top result among the non-English speaking countries. In addition to National Science Council (NSC) funding, science education researchers have been active in applying research resources from the Ministry of Education. Ministry allocates resources for research-based development of instructional materials and other practical sides of teaching and learning in science.

The analysis of research output and influence of the research to science education practices in Taiwan, and internationally, is without any doubt important. This was recognized also by Reinders Duit when he pointed out the impressive development of science education research in Taiwan between the early 1990s and 2013. He states that three issues seem to have played a significant role in this progress: (a) establishing science education as a research field in Taiwan, (b) receiving international support, and (c) becoming familiar with the international state of the art in science education and related research. Another interesting analysis is that the authors of the chapter present here are the influence of research projects to the science teachers' pre- and in-service education and to the adoption of new science curriculum. This is an excellent example how research and development/professional development go together. However, as authors of the sub-chapter state, it would be interesting to clarify in detail if Taiwan had developed a unique theoretical framework for learning and teaching that reflected the country's cultural and demographic characteristics, and whether current research efforts sufficiently inform policymakers so that they can provide continuing policy support to promote quality research.

The authors conclude that in spite of the complexity among the political and socioeconomic backgrounds in Taiwan as well as in many other Asian countries, promising opportunities exist at the individual, regional, and global levels for science educators to improve the quality of science education research, to increase the effectiveness of science teaching and learning at school, and to reach out and educate a wider audience in a range of informal settings.

12.5 Discussion

As it has been described in each summary above and original papers located after this introduction, Asian countries are aiming to improve the quality of science education and science education research, in order to increase the quality of science teaching and learning at Asian schools. Each paper presents a review on progress in science education, science education research and government policy and, moreover, challenges of future development. Therefore, the chapter is valuable and useful for science education researchers and developers of science education. However, there are differences in science education research among the five countries. For example, Taiwan, Singapore, and Oman are countries where the governments allocate resources for science education research. These resources have been used in a clever way and countries have increased the number of high-quality journal publications.

The four papers introduce several interesting science education research themes such as teaching and learning of science, the use of technology in education, motivation and affects, professional development of teachers, and teacher education. Moreover, there is a lot of research in all countries focusing on the outcomes of science education policy like secondary analysis of international comparative studies data. The research have been organized in research groups and it is interesting to read from the papers how the research activities are organized in different countries. Especially, it is interesting to become familiar how

- the research activities are organized in research teams and how research is split into concrete research projects with clear aims and external funding,
- the research outcomes are communicated in international conferences and international journals,
- the groups promote national and international collaboration in the research projects,
- Ph.D. students are recruited to the research projects and research is conducted with Ph.D. students.

However, it would be interesting to know how science education research is coordinated with effective leadership. For example, how senior and young researchers are collaborating and how Ph.D. education is organized on the international level.

Reference

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