Contemporary Trends and Issues in Science Education 45

Ling L. Liang
Xiufeng Liu
Gavin W. Fulmer *Editors*

Chinese Science Education in the 21st Century: Policy, Practice, and Research

21 世纪中国科学教育：政策、实践与研究

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Foreword

When the editors of this book, Ling Liang, Xiufeng Liu, and Gavin W. Fulmer, approached me (and Springer) with a proposal for this book, I was immediately excited and intrigued about the idea of learning about the practice of science education in a part of the globe that remains partially "hidden" from many mainstream sources of scholarship in the field. It was appropriate that our first fact-to-face meeting took place in 2012 in Indianapolis, Indiana, at NARST, where the organization was realizing its new tagline "A Worldwide Organization for Improving Science Teaching and Learning through Research." It was there that three insightful and respected scholars recognized the importance of understanding our field in a global context and using a wide lens to turn that exploration back onto itself with an examination of science education practices and policy in China. Given that China awards a number of advanced degrees in science and engineering equal to or exceeding virtually every country on the planet and is consistently ranked among the top-performing nations in math and science, an examination of the practices associated with the teaching and learning of science is both timely and warranted.

What is interesting, as the editors point out, is the interplay that exists between the unique cultural traditions and values of China and its willingness to integrate research from around the global science education community in ways that are synergistic to that heritage. This balancing act is one that is carefully crafted in a manner that captures the underlying conceptual significance of research conducted in varied settings and translates that work into the Chinese context. This is not to suggest that there is one uniform Chinese context; there are many subcultures and differential community and student needs that need to be addressed. What it does mean is that there is a concerted effort on the part of Chinese science educators to apply, in educationally meaningful ways, the work of the greater science education community. No matter what country we reside in, we need to be vigilant about not becoming insular in our work and in our thinking.

I would never presume to know what it is like to see, think, or feel through an Asian lens. But I do appreciate, in Eisner's (1998) sense of connoisseurship, Asian sensibilities and philosophy. Having studied and practiced a form of Asian martial arts, Isshin-Ryu Karate, for 35 years, and having worked professionally with international colleagues from Hong Kong and Mainland China, Okinawa, South Korea, and Taiwan, I have developed at least a superficial understanding and an unbridled respect for Asian mindsets. Isshin-Ryu provides a good example of what I find quite interesting. Translated, it means "One Heart Way." To practice that art, to achieve the level of a "master," one must realize that the mind, body, and spirit need to work as one, in harmony with the environment and those around you. This is akin to the philosophy of Confucianism that manifests itself in a variety of related philosophies found throughout Asia. At its core, it advances a type of secular humanism that permeates all aspects of Asian culture, including formal institutions, educational settings, social relationships, and the like. I find it quite interesting that the scholars contributing to this volume reflect this core principle in a multitude of ways, sometimes subtly, by concealing multiple meanings just below the surface of the written word, and sometimes overtly, by coaxing the reader to capture, synthesize, and thread connecting ideas together throughout this work. Sometimes, not looking for these relationships is the best approach to finding them, consistent with the Zen-like mindset.

So while the chapters of this book may examine topics familiar to science educators, the manner in which such topics are realized and interpreted likely engenders subtle differences from works expressing, for example, a European or Canadian perspective. The six sections that serve as an organizing theme for this book include Chinese science education reform policies, science curriculum and instruction, environmental and socioscientific issues, science assessment, informal science learning, and science teacher education. The scholars who contributed to these sections reflect perspectives from Hong Kong, Mainland China, and the USA, the latter of which have close ties to Asia.

The editors have crafted well-conceived overviews, advanced organizers if you will, that masterfully provide rich contexts for each of the six sections stated above. I would not, however, be doing justice to these portions of the book by leaving it at that. Each of these section overviews presents a frame of reference, a way of thinking about the works within those sections. Doing so not only enables the non-Asian mindset to enjoy a partial lens into the sociocultural factors that make this work unique but "see" how the writing resonates within the broader science education community. Likewise, the epilogue further embeds these works into a global context. Therefore, the reader has the pleasure of intimately discovering the nuances of Chinese science education as well as the opportunity to position those nuances squarely within the context of our global science education community.

In a recent cross-cultural study examining epistemological orientations and reasoning about socioscientific issues and beliefs about science among students from Jamaica, South Africa, Sweden, Taiwan, and the USA, my colleagues and I found consistent if not universal trends in terms of how students framed their reasoning. Such commonalities are not entirely surprising given how people reflect and contribute to the human condition. Interestingly, however, there were distinguishing characteristics between the Asian (in this case Taiwanese) frames of mind and those of students from other countries in that they scored significantly higher in viewing science as an interrelated network of highly integrated concepts and in terms of conceptualizing scientific understanding and the construction of ideas as reflective and creative acts. Even the Asian students' selection and ranking of "patients" in dealing with aspects of distributive justice in contexts reflected decisions that factored in the patients' broader impacts to others and the community where they resided, indicating a robust interconnectedness to broader societal networks. While we don't presume that Taiwanese students' conceptualizations in this study are isomorphic with all Asian cultures, it did share an underlying current of Confucianism and related Zen-like perspectives as noted above.

It is quite interesting to note that while the concept of systems thinking, coming of age in the second half of the twentieth century, became both popular and useful in thinking about the interconnectedness of themes, patterns, and trends within psychology, biology, sociology, the arts, etc. (Betalanffy 1968; Luhmann 1995; Parsons 1977), the very same idea has permeated Asian culture for hundreds, if not thousands of years, but in much more subtle ways bound up in the Confucianism mindset. The fabric that binds together those orientations forms an epistemological belief system that manifests decisions tempered by forms of benevolence and humaneness in all crafts that are practiced within a community whereby each individual's actions touches others (Shun and Wong 2004). In an educational context, teachers have a responsibility to their students, while students in turn have a responsibility to their teachers. Each is bound to the community by a web of social norms that direct human action toward an arch of dignity, respect, goodness, moral worth, and human fulfillment. True to this philosophy, Professors Liu, Fulmer, and Liang, along with their co-authors, have skillfully crafted a scholarly text that captures how other international works inform the elements of Chinese science education and how other global contexts of science education may be informed by Chinese science education. We all have much to learn from one another.

Tampa, FL, USA Dana L. Zeidler

References

Eisner, E. W. (1998). *The enlightened eye*: *Qualitative inquiry and the enhancement of educational practice*. Upper Saddle River: Prentice Hall.

Luhmann, N. (1995). *Social systems*. Stanford: Stanford University Press.

Parsons, T. (1977). *Social systems and the evolution of action theory*. New York: Free Press.

Shun, K.-L., & Wong, D. B. (2004). *Confucian ethics*, *a comparative study of self*, *autonomy and community*. Cambridge: Cambridge University Press.

von Bertalanffy, L. (1968). *General system theory*. New York: George Brazillier.

Zeidler, D. L., Herman, B., Ruzek, M., Linder, A., & Lin, S. S. (2013). Cross-cultural epistemological orientations to socioscientific issues. *Journal of Research in Science Teaching*, *50*(3), 251–283.

Preface

According to the most recent PISA results released in 2013, Shanghai, China, is the best-performing economy in the world. This repeats the 2009 results, when almost 15 % of students in Shanghai, China, achieved the highest levels of proficiency in all three of the assessment subjects: mathematics, science, and reading. By comparison, the OECD countries had an average of only 4.1 % of students achieving the highest levels of proficiency in all three assessment subject areas. The Shanghai students' consistent top performance in PISA has certainly generated curiosity for people outside China. As PISA seeks to assess not only basic knowledge but also application of that knowledge in situations relevant to everyday life, these results have also challenged the stereotypical image of a Chinese education system that focuses solely on rote learning and memorization. Of course, we understand that, as a municipality directly under the central government, Shanghai is the biggest economic center and one of the most developed regions in China. The science education achievement in Shanghai certainly does not represent what is happening in the entire country. Given that China has the largest science education system and maintains the world's largest supply of science and engineering talents (National Science Board 2012), people in the rest of the world have become increasingly curious about the insiders' stories related to Chinese educational policies, practices, and research. What do Chinese science educators, teachers, and students do to achieve what has been accomplished? What are Chinese students and teachers actually doing inside their classrooms? What educational policies have been helpful in promoting student learning? How do Chinese scholars perceive their successes and/or challenges in the twenty-first century? What lessons can be shared within the international science education community?

The purpose of the book is to answer some of these questions. The chapters provide an overview of science education policies, research, and practices in Mainland China, with specific examples of the most recent development in these areas. Due to differences in language and culture and various other reasons, only a small fraction of science educators and scholars from Mainland China have shared their ideas, research findings, and practices in English science education journals and books to date. Thus, there is a wealth of knowledge and insights that has been out of reach to the international community—especially the Western world. For instance, nowadays, many science educators and/or education researchers in the English world know that "Lesson Study" is an effective teacher professional development process that originated in Japan. However, few people appear to be aware that Chinese teachers have a long tradition in engaging in similar professional development practices called "Collective Lesson Preparation" (CLP or 集体备课in Chinese) in their work routines. The CLP process has provided many formal and informal opportunities for interactions among teachers. In this book, the CLP is introduced as a powerful tool in developing professional learning communities, especially in mentoring novice teachers including student teachers in Chinese schools. As a matter of fact, the CLP is only one of the four most frequently adopted in-service teacher professional development models in China.

As co-editors of the book, we have had the privilege of interacting with many authors in China and conducting collaborative research with some of them over the years. Although we work outside China, all of us have published about Chinese science education research. For example, Dr. Xiufeng Liu edited/authored a volume entitled *Mathematics and Science Curriculum Change in the People's Republic of China* in 1996. Recently, Drs. Xiufeng Liu, Ling Liang, and Enshan Liu have also co-edited a special issue on Chinese science education research in the *International Journal of Science Education* (2012). In the current book, we focus on the major science education reform efforts and changes which have occurred in Mainland China since 2001. This book is unique in the following ways. It is the first comprehensive book that addresses multiple components in the current science education system authored mainly by native Chinese speakers living with firsthand experiences. All section editors are recognized leading Chinese science educators or researchers in the particular field and currently working inside China. The first authors of individual chapters are all currently playing key roles in teaching and/or research in their respective institutions. The chapter contributors include both established and novice Chinese scholars and researchers. Some have completed their doctoral dissertations/theses recently, and some have previously published in Chinese academic journals only. Some graduate students also contributed to the chapters with their supervisors. All chapters have undergone three rounds of internal and two rounds of external reviews. During the first two rounds of internal review, each chapter was examined by a section editor and at least two book editors for content accuracy and significance. The third rounds of the internal reviews were mainly conducted by the three co-editors of the book. The co-editors also provided substantial assistance in content structure and text editing for many chapter authors. Further, Springer provided language editing service prior to the second round of external review. The final version of the entire book was read and edited by both Liang and Fulmer for consistent style and coherent language across the different contributions.

The book is not intended to be an exhaustive review of Chinese science education development, research, or practices. When soliciting chapter proposals, the editors had the following goals in mind:

- Provide a broader overview of the current status of the science education policies, practices, and research in China
- Provide sample empirical studies on some important questions for Chinese science education
- Present unique characteristics of Chinese science education research and practices

The book is primarily written for outsiders using the integrated perspectives of both insiders and outsiders. As insiders, the chapter authors all have the firsthand knowledge of Chinese science education. On the other hand, two of the three co-editors of the book (Liang and Liu) are native Chinese speakers but received doctoral degrees in science education in North America. Both have had personal experiences of K-16+ science education in China and are currently teaching in the USA, while the third co-editor (Fulmer), a native English speaker, has also been conducting some collaborative research with Chinese scholars as an "outsider." Our unique background allows us to integrate both insider and outsider perspectives in writing the section introductions or commentaries. We envision that the primary audience for this book will include science education researchers, comparative education researchers, science educators, graduate students, and state science education leaders and officers in international communities. Some chapters can also be used as supplementary readings for graduate seminars and science education research courses outside of China. Finally, the university faculty of science education inside China may also consider adopting the entire book or certain chapters in their graduate-level research courses. Both Chinese students and science education faculty will find this book helpful as they explore effective ways to share their science education stories and research with the rest of the world.

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Acknowledgments

It has been our privilege and honor to work with chapter authors and section editors from different parts of China. We thank the series editor, Dana L. Zeidler, and external reviewers for their thoughtful comments, as well as Bernadette Ohmer at Springer for providing extensive copy editing service. We are also grateful for the support we have received from our respective institutions, i.e., La Salle University, USA; the State University of New York at Buffalo, USA; the National Institute of Education in Singapore; and the University of Iowa.

Contents

Introduction: Chinese Science Education in a Global Context

China has the world's biggest science education system and maintains the world's largest supply of science and engineering (S&E) talent. As revealed in the Science and Engineering Indicators (National Science Board 2014), as of 2010, more than 5.5 million first university degrees were awarded in S&E worldwide. Students in China comprised about 24 % of these degrees, compared to about 17 % in the European Union (EU), and about 10 % in the United States. In the past two decades, China's capacity for advanced S&E education has also substantially increased. In 1996, China awarded about 4000 S&E doctorates. In 2010, more than 31,000 S&E doctorates were awarded in China, compared to about 33,000 S&E doctoral degrees awarded in the United States, about 16,000 in Russia, about 12,000 in Germany, and about 11,000 in the United Kingdom. Furthermore, in the recent Program for International Student Assessment (PISA) in 2012 and 2009, Shanghai, China, was consistently ranked as the best-performing economy in the world in math, science, and reading. Without doubt, China's science education has become a point of interest in the world, and study of both its quality and quantity could have an impact on the rest of the world.

Despite this potential contribution, participation to date in exchange of knowledge in science education and research by Chinese scholars has been very limited in terms of publications in English-language journals and presentations in international science education conferences. As a result, a few inside stories about the current reforms of the Chinese science education are known to outsiders, especially to the Western world. This is certainly incompatible with the high impact of the rapid Chinese economic development, its contribution to the world's highest share of the S &E talent, and its role in the globalization of science education. The purpose of this book is to give science educators in China an opportunity to tell their own stories of a decade-long reform directly and collectively to the English-literate world. In this introduction section, we provide an overview of the current education system and some historical context of science education in China, followed by a brief description of the sections covered in the book.

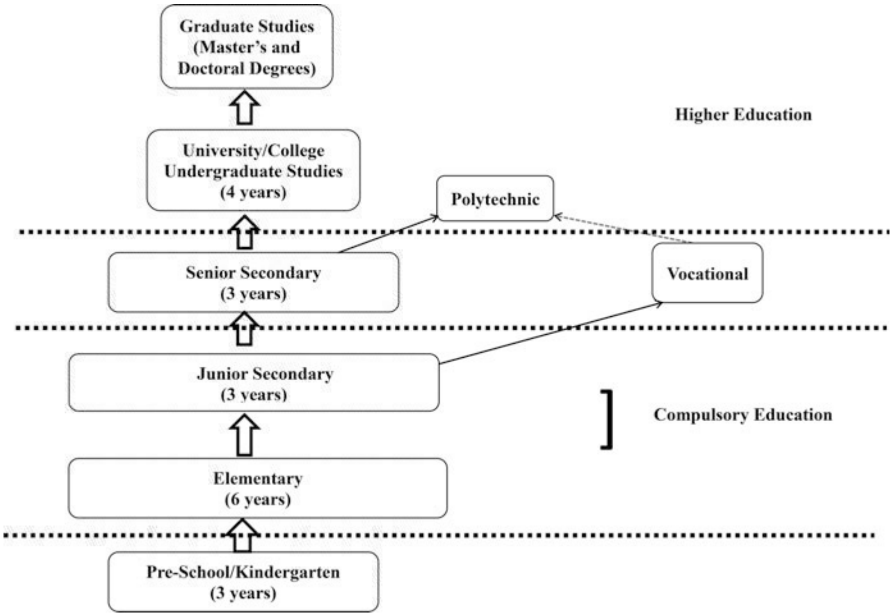

Fig. 1 Structure of the current Chinese educational system

Educational System in China

In the book entitled, *The Clash of Civilizations and the Remaking of World Order*, Huntington (1997) divides the 1990s world into nine major civilizations: Western, Latin American, African, Islamic, Sinic, Hindu, Orthodox, Buddhist, and Japanese. Civilizations as cultural entities are believed to have more enduring influence over educational practices than do political governing systems. Following this civilization-based framework, cultures of mainland China and related Chinese communities in Southeast Asia belong to the Sinic civilization, with Confucianism as a major cultural component. Confucianism, a philosophy advocating self-cultivation, humanism, collectivism, and a hierarchy of human relationships in the society, has been a guiding principle of governmental and educational systems in Chinese history for thousands of years. Chinese people and the government used to be content with a vast society being overseen by a small group of highly educated elite. With the challenges arising from the economic globalization and rapid domestic development in the past two decades, it has become apparent that human capital is the key and a mass education model must be adopted to replace of the traditional elite-oriented education system. Figure 1 illustrates the current structure of the Chinese education system, which consists of the following major categories: early childhood/kindergarten, elementary, secondary, vocational, and higher education including graduate studies. Students with physical or mental disabilities are enrolled in special education schools separately.

In mainland China, there are 31 provincial-level administrative units (including provinces, municipalities, and autonomous regions). The educational facilities and development vary greatly across the nation due to geographical, economical, and political factors. As a response to the demands of an increasingly globalized and highly competitive world, the Chinese government has strived to improve K-12 education and expand enrollment in higher education through issuing and implementing a series of reform policies, establishing new national curriculum standards, restructuring the education system, enhancing decentralization and school-based management, and aiming for quality education for all. In 2014, the kindergarten enrollment rate (for ages 3–5) across the nation reached 70.5 % (MOE 2015). The enrollment rate of school-age children in compulsory education (Grades 1–9) is approaching 100 %, while the higher education enrollment rate (for ages 18–22) was about 37.5 % in 2014. The country is moving toward massive higher education in the twenty-first century. Tables 1 and 2 present the number of students and full-time faculty in 2014 by education levels, respectively.

The latest initiative in China is a national comprehensive campaign to further improve education in the next decade, as articulated in the Outline of China's National Plan for Mid- and Long-Term Education Reform and Development (2010–2020) (MOE 2010). In this document, specific objectives for reforming both basic and higher education through 2020 have been developed and elaborated. It intends to move the nation toward an era of education system promoting quality, equity, and individuality.

Chinese Science Education

Chinese science education can be traced back to 1904 when the government of the Qing Dynasty, the last feudal empire in Chinese history, released a school regulation policy making physics, chemistry, and nature part of school curriculum (Liu et al. 2012). School science was initially imported into Chinese education system almost wholesale by the end of the nineteenth century (Wang 1997), as a result of a craze for Western learning – after the Chinese government was forced to sign multiple "unequal treaties" with foreign powers following repeated military defeats in the modern history of China. The well-known May Fourth movement initiated by college students in Beijing on May 4, 1919, followed by New Culture movement, represented part of a vast modernization movement which sought to reform China through intellectual and social means. Two terms, "Mr. Science" and "Mr. Democracy," were also coined during that time period. Science and technology have since been perceived by the Chinese society as the pathway toward a stronger, independent, and modern China.

The modern Chinese school system with primary, secondary, and tertiary levels was first built on Western models in the early 1900s. Since then, school curriculum

Table 1 Number of students in 2014 by education level

Pre-school/ kindergarten	Elementary school (1–6)	Junior secondary school (7–9)	Senior secondary (10–12)	Special education schools	Undergraduate (4-year)	Graduate	
						master's	doctoral
40,507,145	94,510,651	43,846,297	24,153,687	394,870	15,410,653	1,535,013	312,676

MOE (2015)

Table 2 Number of full-time teachers/faculty in 2014 by education level

Pre-school/ kindergarten	Elementary school (1–6)	Junior secondary school (7–9)	Senior secondary (10–12)	Special education schools	Undergraduate (4-year)
1,844,148	5,633,906	3,488,430	1,670,720	48,125	1,091,654

MOE (2015)

and organization have been influenced by the systems of multiple countries including Japan (at the beginning of the twentieth century), the United States (1920s–1940s), and the former Soviet Union (1950s). During the Cultural Revolution (1966–1976), the school system was largely dismantled during the upheavals in a chaotic society. In 1978, the Chinese government announced and adopted the "reform and opening-up policy" led by Mr. Deng Xiaoping, a top government official and advocate for promoting economic and educational reforms. Since then, many foreign textbooks and scholarly works and materials have been translated and imported to China, while government-sponsored Chinese scholars have also been sent to developed countries to study international trends in learning and instruction, and the development in curriculum and standards.

As a result of the intellectual exchanges and international influences, Chinese science education has gone through the following major stages after 1978 (Wang 2012; Wei and Thomas 2007): (1) The recovery period of the conventional school science curriculum ruined by the Cultural Revolution, from 1978 to mid-1980s. Influenced by science curriculum reforms in the USA and other Western countries in 1950s and 1960s, the main goal of school science was to prepare future scientists and engineers by placing limited resources into a small number of so-called key schools to promote the education of "elite" students. (2) Science curriculum reform in the context of compulsory education, from late 1980s to 1990s. Influenced by the call for "science for all" in the West in the 1980s, China transformed its elite-oriented education system into a mass education system. Both foundational scientific knowledge and basic science skills were emphasized. (3) Curriculum reform in pursuit of quality education, from the end of the twentieth century to the present. Influenced by the literature on the development of "scientific literacy" in the West, the traditional focus of school science curriculums has been expanded into the three-dimensional goals involving the development of scientific knowledge and skills, scientific process and methods, and scientific attitudes and values. This reform also intends to transform the exam-oriented school education into a quality-oriented one emphasizing student development. About 10 years after the release of the trial version of the national science curriculum standards in 2001, the revision of the science curriculum standards was first completed at the junior high school level and published in 2011. The revision of the elementary science standards and the senior high school science standards are still works in progress.

Although the recent development of Chinese science education has been influenced by foreign ideas, the adoption of educational approaches or ideas from foreign countries has never been a process of simple imitation. Many Chinese educators and curriculum scholars, deeply influenced by the Chinese cultural values and heritage, adopt a generally pragmatic view of treating or borrowing foreign ideas: ie, borrow or apply foreign ideas only if they are applicable to the Chinese context (Wei and Thomas 2007). The new round of science education reforms that China has implemented are likely of interest to readers outside China who wish to learn about the current status of science education in China. This book addresses that interest. In its chapters, we present research findings, reflections, and syntheses by many science educators who have played key roles in science education reforms in China over the past decade.

Sections in the Book

In this book, we cover six areas of Chinese science education: science education reform policies, science curriculum and instruction, environmental and socioscientific issues (SSI) in science education, science assessment, informal science learning, and science teacher education. While focusing on China, we also address broader implications about science education worldwide through editors' section introductions and commentaries from an international perspective.

In Part I, Chap. 1, Zhang provides an overview of recent and ongoing science education reform initiatives in China. Specifically, this section reviews major curriculum reform initiatives in elementary and secondary schools, science teacher education, science education research, science education system, science education program evaluation, and informal science education. This chapter provides background on and policy foundation for the subsequent chapters presented in the rest of the book.

Part II, including both literature reviews and empirical studies at K-12 levels, provides a status report on the reformed curriculum and classroom practices in early childhood science education, basic compulsory science education (Grades 1–9), and senior secondary science education (Grades 10–12).

In Part III, the chapter authors examine the current practices of school environmental education and discuss challenges and opportunities of environmental education toward education for sustainable development in Chinese communities. In Chap. 7, Cheng and So describe transitions in the educational policy on environmental education in Hong Kong and mainland China with a comparison to Taiwan. This chapter shows how the policies reflect changes from a focus on protecting the environment toward the concept of education for sustainable development (ESD). In Chap. 8, Lee addresses work on socioscientific issues in Hong Kong and parallel study in southeastern mainland China. Through four studies, he demonstrates how students reason about SSI and examines some of these findings' similarities with and differences from those of Western counterparts.

In Part IV, the chapter authors examine assessment in science education in China from a variety of perspectives ranging from the national to the classroom level. The chapters describe the current policies on assessment in science education within

China, examine the alignment of standardized tests with the associated national curriculum standards, and explore teachers' conceptions of assessment. The chapters will prove valuable reading for colleagues interested in understanding current policy and practice for assessment in science education in China.

In Part V, Chaps. 12, 13, 14, 15, 16 by researchers at the China Research Institute for Science Popularization provide both an overview of informal science education policies and practices and sample research studies in China. Informal science education research is still in its infancy in China; this set of chapters represents the current state of the art for research in this area in China.

Part VI is on science teacher education. First, typical pre-service science teacher preparation programs and the four most common professional development models for in-service science teachers are presented. This is followed by an empirical study on junior secondary biology teachers' misconceptions and its implication for enhancing science teacher professional development. The last chapter authors describe the use of a video case instruction approach designed for pre-service chemistry teachers. Teacher candidates' perceptions of the intervention are also reported.

Finally, in the epilogue, the co-editors of the book summarize the successes and challenges faced by Chinese science education as presented in the individual chapters. Then, we further discuss some broader implications about science education in the international community, followed by recommendations and suggestions for potential collaboration and research. We hope this book will inform science educators around the world on the current status of policy, practices, and research activities in science education in China in order to further facilitate intellectual exchanges between China and the rest of the world.

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References

Huntington, S. (1997). *The clash of civilizations and the remaking of world order*. Viking: Penguin books.

Liu, X., Liang, L., & Liu, E. (2012). Science education research in China: Challenges and promises. *International Journal of Science Education*, *34*(13), 1961–1970.

Ministry of Education (MOE). (2010). *Outline of China's national plan for medium and long-term education reform and development (2010–2020)*. [国家中长期教育改革和发展规划纲要

(2010–2020)]. Retrieved from http://www.gov.cn/jrzg/2010-07/29/content_1667143.htm (in Chinese).

Ministry of Education. (2015). *Educational statistics in 2014*. (2014年教育统计数据). Retrieved from http://www.moe.gov.cn/s78/A03/moe_560/jytjsj_2014/2014_qg/ (in Chinese).

National Science Board. (2014). *Science and engineering indicators 2014*. Arlington: National Science Foundation (NSB 14-01). Retrieved from http://www.nsf.gov/statistics/seind12/c0/c0i.htm

Wang, J. (2012). Curriculum reform in mainland china, 1978–2008. *Chinese Education and Society*, *45*(1), 59–68.

Wei, B., & Thomas, G. P. (2007). The post-Mao junior secondary school chemistry curriculum in the People's Republic of China: A case study in the internationalization of science education. In B. Atweh et al. (Eds.), *Internationalisation and globalisation in mathematics and science education* (pp. 487–507). Dordrecht: Springer.

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Part I
Science Education Reform Policies

Xiufeng Liu

Editor's Introduction: Part I

Education is always closely tied to a country's cultural and political systems. After analyzing the mathematics and science curriculum changes from China's founding in 1949 to the mid-1980s, Liu (1996) concludes that Chinese mathematics and science curriculum changes were the direct result of the social and political changes taking place in the country and a "thermometer of the country's social and political climate" (p. 152). Liu's conclusion applies to the recent science education reforms outlined in Chap. 1. Specifically, although the country's open door to foreign investment policy and market economy started in the late 1970s, major economic reforms that have been transforming the country have only been taking place over the past 20 years or so. There were a few significant political and economic events taking place during this period. During a Chinese New Year visit to southern China in early 1992, China's "paramount leader" at the time, Deng Xiaoping, made a series of political pronouncements intended to further stimulate the country's economic reforms. The 14th National Communist Party Congress later in the year officially adopted Deng's bold vision for market economy-oriented reforms, identifying China's key task in the 1990s as creating a "socialist market economy." In November 2001, China officially joined the World Trade Organization (WTO), marking a milestone in its open-door economic reforms. With significant foreign investments and domestic economic stimuli, such as designating various special economic zones in coastal cities, China has been able to maintain an annual economic growth rate of above 8 %. In 2010, China became the second largest world economy after the USA. The rapid economic development engineered by the Chinese central government has created not only a need to reform its science education in accordance with science education reforms in developed countries but also the financial capacity to implement these reforms. As Zhang and Wan state in Chap. 1, Chinese science education reforms in K-12 curricula, teacher education, informal science education, and so on have been influenced by science education reforms in the USA and other developed countries, consistent with its open-door economic reforms.

Chinese education system is a highly centralized one, and any reforms in Chinese education must be understood within such a centralized context. Although Chinese science education reforms reviewed in Chap. 1 are aligned with science education reforms in developed countries, there are noticeable differences between China and developed countries such as the USA. One obvious difference is that Chinese science education reforms are top down. It is clear from Chap. 1 that every initiative can be attributed to a Chinese central government directive or policy document. For example, the ongoing science curriculum reforms in the elementary and secondary schools were initiated by the 2001 Chinese Ministry of Education directive entitled "Outlines of Curriculum Reform in Elementary and Secondary Education" (MOE 2001). The top-down science education reform is also characterized by systematic implementation. On the other hand, in many developed countries including the USA, science education reforms are often initiated by nongovernmental and professional organizations, indirectly supported by federal governments and followed by voluntary implementation by local governments. This difference is obviously due to the difference in education systems.

The Chinese education system can be characterized as a centralized system because:

1. The teaching program, which prescribes the aims of public education, the school system, subjects to be taught, objectives of each subject teaching, and teaching hours for each subject, is stipulated by the Ministry of Education of China.
2. The content standard and teaching syllabus for each subject, which prescribes objectives, principles of instruction, topics to be taught in the subject, and teaching hours allocated to the subject teaching units, are stipulated by the Ministry of Education of China.
3. Textbooks for each subject of each grade are developed by publishing houses approved by the Ministry of Education and reviewed by a national expert panel appointed by the Ministry of Education of China.
4. The unified high school entrance examination covering all major school subjects is conducted by local education authorities, and the unified university entrance examination covering core school subjects is conducted by a testing agency directly affiliated to the Ministry of Education in coordination with a similar testing agency directly affiliated to the provincial Departments of Education.

Comparing centralized education systems with decentralized education systems such as that in the USA, one clear advantage is that any reform initiative can be implemented nationally in a relatively short time period. Within a decentralized education system such as that in the USA, there have been numerous examples of reform initiatives that have not been fully implemented. Ravitch (2000) reviewed over a century of US school reforms, particularly curriculum reforms, and found that they can be characterized as being disconnected, fragmented, and certainly not fully implemented. Even with such federal legislation as No Child Left Behind (NCLB) in 2001, curriculum reforms remain more a slogan than substance due to a