Development of Science Teachers' TPACK

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Editor

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East Asian Practices

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Preface

Teaching with technology has been widespread around the world for many years, and it continues to increase and change with greater access to and variety of technologies. Taking the United States as an example, at least one computer was available in 97 % of its classrooms in 2009 (Gray, Thomas, & Lewis, 2010). The fever about pursuing electronic classrooms has spread to developing countries. Zhang (2007) reported that governments of most Eastern countries launched projects or reforms in classrooms since 2000 to infuse information and communication technologies (ICT). As early as 2002, Taiwan, Hong Kong, and three other Asian countries were listed among the countries with high ICT access (International Telecommunication Union, 2003; Ono, 2005). The Ministry of Education in Taiwan announced the *Blueprint of Information Education in Elementary and Junior High Schools* (Ministry of Education, 2008) to strengthen students' technology literacy, which included increasing the hours for information courses in the curriculum and enhancing teachers' technology application abilities. This call for technology literacy should not be confused with engineering/technology literacy advocated as part of the science, technology, engineering, and mathematics (STEM) initiative in the recent framework of science education in the USA (National Research Council [NRC], 2012; Yore, 2011); but ICT literacy is a contributing component to these science, mathematics, and engineering/technology literacies.

It appears that in Asia the technological hardware, software applications, and curricular authority are in place. Demands for teacher education to refine science teachers' technology usage are needed in Taiwan, Hong Kong, and elsewhere. Sung, Chang, and Hou (2005) pointed out that most of the teacher education courses in Taiwan regarding ICT literacy emphasized technological skills and lacked meaningful connections with pedagogy or subject area content. Practicing teachers reported positive attitudes toward technology implementation and knowledge about constructivist approaches as being effective strategies when teaching with technology, but their actual implementation was limited (Chen, 2008). As for the situation in Hong Kong, Fox and Henri (2005) found that teachers' teaching practices with technology changed little due to the administrative overloads and busy work even though the government introduced a policy that promoted a shift of curriculum and instruction to a student-centered focus. Gaps are common between teachers' actual implementation of technology and their knowledge levels or the expectations others place on them regarding teaching with technology. Some other problems that may discourage teachers' use of technology included the lack of teaching experience, negative perceptions of technology, insufficient on-site time, and technical or financial support (Mumtaz, 2000).

Clearly, helping teachers to teach with technology is critical to contemporary education since it will meet the needs of *Net Generation* students, capitalize on the potential of ICT to enrich and expand learning opportunities, and increase the effectiveness of the learning–teaching experience. Teachers' use of PowerPoint presentations to deliver their instruction in an organized way is a good first step to ICT-enriched instruction. However, there are still more profound possibilities where technology can be used to serve teaching and learning needs. Flexible uses of technology to realize content knowledge delivery and student learning are worth pursuing, such as through presenting natural phenomenon or allowing students to do simulated experiments in classrooms. It is only when teachers possess Technological Pedagogical Content Knowledge (TPACK; Mishra & Koehler, 2006) that would enable them to design and implement instruction with best considerations of students, curriculum, and technology. Assuming that the quality of teachers' technology utilization partially determines the quality of students' learning effects, then professional development of teachers' TPACK deserves a fuller investigation to identify what can be done better.

Purpose of the Book

The Science Education Center at National Taiwan Normal University has been exploring topics of science teaching and learning and designing technology-enabled science instruction for years. With these longitudinally academic research endeavors, the Center received grants from the Aim for the Top University Project that is funded by the Ministry of Science Education in Taiwan for making an overall improvement for science education in terms of science learning, teaching practice, policy, and research. This book tries to report on what the Center and its associates have done in promoting science teachers' instructional knowledge in teaching with technology and how they refine their science instruction with technological supports. Important TPACK issues, professional development, and teacher development are discussed, including theoretical and practical concerns, knowledge framework construction and evaluation rubrics, and actual observations on science teachers' TPACK development.

Organization of the Book

As Sir Isaac Newton wrote in a letter to Robert Hooke in 1676, "If I have seen further it is by standing on the shoulders of giants." Relying on the works of Shulman, Mishra, Koehler, Angeli, Valanides, and some other researchers, we propose a TPACK framework called TPACK-Practical (TPACK-P) within which teaching practices play key roles in contextualizing and evolving teachers' knowledge in teaching with technology. Some related empirical studies that we have done based on TPACK-P to investigate and develop science teachers' TPACK are reported in chapters. In order to make the book more diverse in its content, we invited some researchers who use an integrative TPACK framework to share with us their research findings in some chapters. Hopefully, with empirical studies based on two major but different TPACK frameworks, we can provide our readers a comprehensive understanding of the development of teachers' TPACK and stimulate further studies that inform teacher education programs.

Part I – TPACK in Teaching Practices

Part I reports how TPACK is epistemologically defined and actually shaped. Most of the current TPACK frameworks were heuristic based, that is, trying to find out what constitutes teachers' TPACK and to seek ways to further refine current teacher education. In this section, we are eager to unveil how TPACK is composed from practical teaching and learning contexts such as in science classrooms. We think sketches of the TPACK that teacher educators and science teachers have would inform the current development status of teachers' TPACK and provide insights about how we can work on and with it. In Chap. 1, we provide a brief overview introducing why TPACK is viewed as a strand of teachers' pedagogical content knowledge (PCK) and how the conceptualizations of the integrative frameworks and transformative frameworks inherited from PCK were instrumental in our view of TPACK. With the basic understanding of these two different schools of thought on the development of teachers' instructional knowledge, this chapter also raises the importance of *students* and *content* in teachers' TPACK development and classroom implementation. Chapter 2 begins with a synthesis of the frameworks and factors that we have known about TPACK based on previous research findings. The study that informed this chapter focused on knowing more about how TPACK is carried out within an actual teaching context. The authors invited a research panel and an expert teacher panel to participate in a Delphi survey to identify a practical framework of TPACK that teachers develop for and from actual teaching contexts. The authors in Chap. 3 documented inservice science teachers' use of technology when they designed their own curricula, enacted their teaching, and assessed their students' learning progress. Profiles of teachers who develop their TPACK-P with different proficiency levels are presented. Chapters 2 and 3 will familiarize readers about what TPACK-P in science teaching practices looks like and how we can strengthen science teachers' TPACK-P.

Part II – The Transformative Model of TPACK

The chapters in Part II take the transformative approach to view the development of teachers' TPACK. In Chap. 4, we try to construct rubrics that can be useful for evaluating preservice teachers' performances regarding lesson planning and microteaching in technology-infused classrooms. Though limited in number of participants, profiles of the seven preservice teachers' lesson plans and microteaching performances were carefully analyzed, suggesting directions for future teacher education. The longitudinal, complicated, and dynamic development varied for these TPACK exhibits, which makes knowledge measurement a difficult task. Findings from this chapter are expected to make contributions to the literature of TPACK measurements. In Chap. 5, the authors propose a teacher community of practice in which teachers with different proficiency levels in TPACK work together, not only for developing android applications (APPs) on multitouch tablets to facilitate students' physics learning but also for strengthening each others' TPACK-P for better accommodating student learning.

Part III – The Integrative Model of TPACK

Part III takes the integrative perspective to view the development of teachers' TPACK as an alternative perspective in applying TPACK in teacher education. Authors in Chap. 6 propose a model, MAGDAIRE (modeled analysis, guided development, articulated implementation, and reflected evaluation), to foster preservice teachers' ability to integrate ICT and teaching. They discuss how MAGDAIRE significantly increased preservice teachers' Flash knowledge and skills facilitated the development of their TPACK-Flash and led to better integration of the knowledge components. In Chap. 7, Hong Kong teachers' use of multimedia resources is analyzed using the TPACK framework to provide tangible understanding of how technology supports teaching and learning in elementary schools. Data collection included a revised questionnaire on TPACK and lesson observations of teachers' use of pedagogies with follow-up interviews, which provided some useful information to enhance our understanding of how multimedia resources are used in primary classrooms and initiated ideas about elementary teachers' teaching practices with technology.

Part IV – Epilogue

Chapter 8 provides external reflections and an international perspective to Chaps. 1, 2, 3, 4, 5, 6, and 7. Since this book discusses the development of teachers' TPACK in teaching practice, the Epilogue comments on how efficient these teachers or teacher educators were in the development of TPACK from epistemological and practical points of view. Insights for constructing a more teacher- and learner-friendly classroom with ICT implementation are offered.

Throughout this book, we would like to share with our readers what TPACK looks like when science teachers apply it in their teaching practice as well as what we have done in developing science teachers' TPACK from different perspectives. Perspectives and findings mainly from Taiwan and some from Hong Kong may not depict full pictures of the science teachers in the digital era in Asia or around the world. However, we expect these studies can be cases that give future researchers or educators insights about how educational negotiations between teaching and technology can be made. At the same time, we also look forward to more studies that investigate how science teachers can better teach with technological applications that include fundamental considerations of pedagogical concerns, science knowledge, and the dynamics and diversity of students and teachers. Technology can be constructive to student learning only if it is properly used and meaningfully engaged into instruction. Otherwise, technology can be a tool like blackboards that serve only as a knowledge displayer instead of a knowledge facilitator.

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Contents

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