

## Chapter 8

# The End of the Beginning: An Epilogue

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This final chapter serves as the epilogue, as both a summary and a synthesis of the chapters in the book. We begin by providing an informal historical overview of the current impact of TPACK as a theoretical framework in terms of the quantifiable reach of the theory as well as the rapidity and breadth of its acceptance. We then provide an overview of each chapter that includes, first, how they are grouped thematically and, then, its core ideas. For Chaps. 2, 3, 4, 5, 6, and 7, we identify and summarize a few key takeaways and points of interest. Following this overview, we identify three crosscutting themes: the importance of the idea of learning by design for the development of TPACK; an emphasis on the evaluation and measurement of TPACK; and, finally, the important role that communities of practice play in TPACK development. We note how learning by design is relevant because several of the studies here involved educators working through the design process (creating software applications, lessons, and other teaching artifacts) to extend it into the arena of TPACK research. Evaluation/measurement is important as well because the work in this book seek to develop rubrics that would allow teacher educators to evaluate different facets of TPACK. Communities of practice were also relevant because, rather than looking at teachers in isolation, the work in this book represents settings that support partnership/teamwork between preservice and in-service teachers (as well as educational researchers, teacher educators, and others). Finally, after considering these points, we offer a note of both positive points and constructive critique regarding this book's potential contributions to the internationalization of TPACK research.

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Now this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.—Winston Churchill (November 10, 1942)

It gives us great pleasure to write the epilogue for this collection of research articles related to technological pedagogical content knowledge (TPACK). The idea of TPACK has truly had a significant impact on the research and practice in educational technology. Speaking personally, it was sometime in 2000 that Matt Koehler and the first author started working together on the learning by design seminars. These seminars, which ended up becoming a book entitled *Faculty Development by Design* (Mishra, Koehler, & Zhao, 2007), were an intervention that attempted to get faculty in higher education to intelligently integrate technology in their teaching. It was while we were conducting research on the process by which faculty working in design teams with graduate students came up with solutions to technological and pedagogical problems of teaching subject matter that the initial idea of TPACK came to us. At that point, it was an inchoate form of understanding—and one that needed further research to elucidate. What I do know is that both Matt and I had a sense that we were closing in on an interesting idea and one that we needed to share with the world. It was around 2004 that we begin writing the article that would finally be published in *Teachers College Record* in 2006.

To say that this article changed our lives is an understatement. The article has over 2,000 citations in Google Scholar. It in turn led to the *Handbook of TPACK* published by Routledge and the American Association of Colleges of Teacher Education (AACTE, Herring, Mishra, & Koehler, 2008). For instance, a quick review of the public Mendeley bibliography connected to the TPACK.org website reveals that there are over 630 publications tagged as being related to TPACK (35 book chapters, 220 conference papers, 15 miscellaneous pieces, and the remainder are journal articles). That is a staggering number of publications—for a topic that was introduced to the research and scholarly community less than a decade ago. In more practical terms, the TPACK framework has been used for faculty development in higher education; it has become an integral part of teacher education and teacher professional development in many countries around the world; and it has been accepted as a guiding framework by a range of educational organizations. As must be clear, the rapidity and breadth of acceptance of the framework have been incredibly gratifying to us. Also gratifying is this opportunity to read all the chapters in this book and to be asked to write an epilogue.

That said, we approach this task with humility; and we do so for two key reasons. First, because though one of the authors of this epilogue is identified as being one of the originators of the framework, we know well that there are many others who have made similar arguments but were not lucky enough to receive the recognition we did (We have in our writing attempted to provide credit to these precursors of the TPACK framework as often as we can.). Second, and as importantly, we understand that the literature on TPACK has grown so quickly that it is nearly impossible for us to keep up with all the work being presented and published. In fact, it can be argued that there are other scholars who are more up to date with the TPACK literature. Given these two facts, it must be understood that this chapter not be seen as a definitive *reading* of this book but rather as one possible review.

## 8.1 Broad Strokes: Overview of the Outcomes

At the broadest level, this book is concerned with the critical issue of teacher education in developing TPACK. And as readers will have noted, the chapters of the book are organized around three central themes of TPACK development, which include TPACK in Teaching Practices, The Transformative Model of TPACK, and The Integrative Model of TPACK.

The overarching focus of this book—examining ways to improve teacher education for the development of TPACK—is relevant and essential to our global and technology-driven society. By improving the way that current and future teachers teach with technology, the field of education ensures that we will meet the needs of twenty-first-century students. Building on the potential of technology offers us a way to enrich and expand learning opportunities and to expand the types of experiences that teachers and learners can have in the classroom.

One of the critical contemporary issues in teacher education has involved how to better support preservice and in-service teachers in the way that they teach with technology. Mishra and Koehler (2006) suggested that this could be well addressed through developing TPACK with the engagement of instructional frameworks, proper assessments of knowledge and practices, and teaching practices for specific learning and teaching contexts. The pre- and in-service focus on educational technology in the chapters of this book highlights an area of teaching and learning that is at the crux of modern education globally. The different frameworks and approaches applied by these authors, along with the different aspects of TPACK they investigated, offer some valuable insights for teacher education and professional development. They are significant as a first step toward a more research-based and informed look at how TPACK is operating in different aspects of teacher learning. Several interesting strands of research arise as we look across the chapters.

### 8.1.1 *TPACK in Teaching Practices*

Chapters 2 and 3 are focused on understanding the ways that TPACK is instantiated in practice. Chapter 2 highlights the fact that there has been much research done to consider and study the models and variations of TPACK for different contexts (e.g., TPACK-deep, TPACK-W). As we see it, there is a research gap in which there has been a lack of work examining working models of TPACK within more subject-specific contexts, such as science, mathematics, etc. This is an interesting gap, particularly when we consider the fact that TPACK itself is so tied to content and the way that content explicitly alters teaching practices and uses of technology. It stands to reason that more diversity within models of TPACK could be useful in subject-/content-specific approaches, and this was a core aspect of Chap. 2. A two-strand panel of researchers and expert teachers helped to generate and validate a TPACK-practical (TPACK-P) framework. The knowledge of learners, knowledge of classroom instruction, and knowledge of curriculum design components that they

describe not only maps on to existing aspects of TPACK but also considers some subject-specific issues. For example in teaching science content, diversity of representations is particularly meaningful and holds unique considerations for technology. The possibility for a more detailed set of subject-specific models of TPACK is a fascinating and useful approach for adding to the existing body of more generalized TPACK work; we concur with the authors that more work is needed in this area.

In Chap. 3, the authors studied novice and experienced science teachers to better understand their TPACK-P knowledge. They did this via interviews with 40 science teachers to reveal their TPACK-P (along the lines of assessment, planning and designing, and teaching practice). The coding schema they developed is interesting in that it provides the field of TPACK research with three categories of teacher knowledge: infusive application, transition, and plan and design emphasis. These three categories hold possibilities for understanding different levels of teacher fluidity with TPACK, from the more infusive (expert) group to the transition group, and to the plan/design group (who seemed more comfortable with lesson planning and preparation of technology-driven lessons than the actual implementation). This analytical breakdown of different levels of TPACK understanding is significant in that it provides support to teachers at different places in the process of knowing and implementing technology approaches in their teaching. As the authors suggest, the patterns shown in this chapter can become a guiding framework for the development of instruments that evaluate teachers' competence in using classroom technologies. More importantly, it gives us a way to see what they do well and where they struggle. In this sense, it is a useful diagnostic approach to giving teachers (and teacher educators) a look at where they are, and where they can go, when it comes to teaching with technology.

### ***8.1.2 The Transformative Model of TPACK***

Chapter 4 puts a focus on research that seeks a deeper understanding of how TPACK is evaluated in science teaching. Specifically, the authors created and tested rubrics to evaluate preservice teachers' TPACK-P; and these were developed according to the proficiency levels and features previously identified about in-service teachers. They collected lesson plans and microteaching video clips of preservice teachers working on physics curriculum and instruction design. Interestingly, results revealed that these preservice teachers' performances on lesson planning and microteaching were similar within one level of proficiency. However, their performance on teaching with technology was comparatively better in curriculum design and enactment than on assessment. In other words, new and future teachers have an easier time in the planning/enacting of technology lessons than with assessment.

In Chap. 5, the authors explore a teacher community consisting of a teacher educator, four experienced physics teachers, and 11 preservice teachers who collaborated with each other on developing simulation-based physics learning modules. With experienced teachers designing software applications (Apps) or learning modules,

the preservice teachers played the role of not only users who implemented the Apps but also testers/evaluators of the Apps. This study presented an interesting case of learning-through-design work for technology implementation and knowledge; it did so in a model that worked for different proficiency levels. The more experienced App designers refined their TPACK-P while producing and reflecting on the artifacts. And the testing and evaluation process gave the preservice teachers an opportunity to experience variables and visualize the phenomena and how it operates in teaching and learning settings. More importantly, this chapter reflects the way that communities of practice can be invaluable in teaching with technology situations. The novice teachers were able to learn from and with the expert teachers and vice versa; and the design-centered approach made the task valuable to teachers at all proficiency levels, giving them a chance to grow their TPACK in practical ways.

### ***8.1.3 The Integrative Model of TPACK***

Chapter 6 bases its work on the theoretical framework of cognitive apprenticeship. The authors apply the MAGDAIRE model (modeled analysis, guided development, articulated implementation, and reflected evaluation) to help preservice teachers become more sensitive to the interplay between the elements of TPACK. This model seemed to be a useful framework for allowing preservice teachers to consider how technology connects to their teaching practice based on a set of variables. The authors found that the preservice teachers they worked with moved toward a more connected look at the ways that technology intertwines with teaching school subject matters. We liken their model to an effective mingling of the cognitive apprenticeship learning theory with a detailed learning-by-design framework. In this, it provides an approach to improve preservice teachers' TPACK that is supportive, collaborative, and systematic (tapping the knowledge of expert teachers for novices, within a guided framework).

In Chap. 7, the authors had teachers utilize e-learning resources of four science topics in the primary curriculum in order to observe and learn from the ways in which they applied this technology. The results from the 19 teachers invited to use these e-learning resources in their classrooms showed some specific understandings of how technology supports teaching and learning. The range of findings seemed valuable for presenting a look at how teachers use technology in a very broad context. Though this work was done in Hong Kong, many of the issues that arose have applicability in many other countries and settings (certainly in the USA). Some of the teachers' initial concerns about technology implementation included the following: worrying whether implementing such activities would affect the teaching schedule and, consequently, students' examination results; the adequacy of different technology equipment; the importance of the teaching materials matching the content of the textbooks or school-based curriculum. These are similar to broader issues faced by all educators who seek to intelligently incorporate technology in their teaching. The authors also note a need for flexibility, in that teachers might need to

modify technology resources or content to fit the resources. But most importantly, they derive the conclusions that (a) there is no right way to integrate technology into the classroom and (b) applicability is highly variable based on the classroom and the context.

## 8.2 Thematic Issues

### 8.2.1 *Learning by Design*

One important guiding theme that we found interesting and important throughout several of these studies was that a type of learning-by-design framework was sometimes implemented to help teachers learn and expand their TPACK. Learning by design is an approach in which learners construct their knowledge through the process of creating something (Kafai, 1995)—quite literally, learning by going through the design process (Shaltry, Henriksen, Wu, & Dickson, 2013). In recent years, this approach has increased in significance in learning/technology research, especially in relation to constructionist frameworks (Peppler & Kafai, 2010; Wiggins & McTighe, 2005). Several of the studies involved instances of educators working through the design process (creating applications, lessons, and other teaching artifacts), which extends the learning-by-design approach into the arena of TPACK research. Some of this design work invites preservice and in-service teachers to work together, which is an approach that fits well with TPACK understandings and with the dynamic and social interplay of the factors that make it up. Mishra and Koehler (2006) suggested that learning by design is a foundational way of thinking and learning, in building a mindset for TPACK. We highlight this point because the development of TPACK is a relatively sophisticated type of expertise that takes educators time and efforts across years to develop. But in a fundamentally important way, the learning in practice that happens in design-based approaches is an excellent way to set the stage for this among new and future teachers. In the case of practicing teachers, it is an approach to honing their craft and taking their TPACK to the next level, using the skills of a designer.

### 8.2.2 *Evaluation and Measurement*

Evaluations of teaching often happen instinctively in the classroom, and they can be a relatively subjective area of teacher education. It is an innately subjective and human activity to observe and make judgments about approaches to teaching and methods of interacting with students, ideas, and technology. It is important, however, that we go beyond mere subjectivity in evaluating teachers, particularly in a realm of teaching as relatively recent as TPACK and digital classroom technologies.

As Lord William Thomson Kelvin once said, not being able to measure what it is that we are speaking of is a “meager and unsatisfactory” kind of knowledge (as cited in Mishra, Henriksen, & Deep-Play Research Group, 2013, p. 11). Toward this purpose, we applaud the efforts of the work in this book aimed at developing rubrics that would allow teacher educators to evaluate different facets of TPACK. The studies in the book are relatively exploratory in entering new territory of educational evaluation. However, the efforts are significant in that they contribute not only through providing some original and early gauges of TPACK in preservice teacher education, but may also be useful for in-service teachers to know their level of proficiency. In fact, the research-based methods for such rubric development constitute a valuable thing as well, for providing the foundations for others to develop new TPACK rubrics in context. It is only through understanding where we are at that we are able to move forward; by offering such measures to teachers, we can help them in their TPACK growth.

### 8.2.3 *Communities of Practice*

The work in this book represents substantive TPACK research and findings that were frequently derived through collaboration, communication among teachers, and communities of practice. We were interested and encouraged to note that several of these studies put teachers in a position of learning and developing their TPACK together. Rather than looking at teachers in isolation, the work in this book represents settings with supports and partnership/teamwork between preservice and in-service teachers (as well as educational researchers, teacher educators, and others). Lave and Wenger (1991) showed how communities of practice (e.g., groups of teachers) offer opportunities for learning through informal apprenticeship models. The role of preservice teachers in several of these chapters maps nicely onto this view of learning and fits well with the way that teachers actually operate and learn to teach in the real world of classrooms. This situates the research in a collaborative learning framework and the best possible situation for authentic approaches to TPACK development.

Brown, Collins, and Duguid (1989) described authentic activities as “the ordinary practices of the culture.” (p. 34). We note that learning through collaboration is clearly ordinary/authentic practice for teachers. Often times, such situative learning happens during an internship or another field experience. However, the opportunities demonstrated in this research present new avenues for building TPACK through discussion, collaboration, and/or design practices among new and experienced teachers (Shaltry et al., 2013). As Granger, Morbey, Lotherington, Owston, and Wideman (2002) put it, “Like effective leadership, the importance of collaboration cannot be overestimated: teachers need each other—for team teaching and planning, technical problem solving assistance and learning” (p. 486); we think that this translates clearly onto the TPACK research settings in this body of work.

### 8.3 A Positive Note ... and a Point of Critique

For historical, and other contingent, reasons most educational research (and educational technology research) has generally happened in North America, specifically the USA. This is true of TPACK-related research as well. Although exact figures are difficult to come by, a recent review by Chai, Koh, and Tsai (2013) indicated that approximately 65 % of the studies selected were conducted in North America. Europe and the Asia-Pacific region were evenly matched at around 17 %.

Given the forces of globalization and the spread of technology, it is clear that there needs to be a better, and fairer, distribution of research. This is particularly true when we think of the important role the *dotted circle* (Chap. 1) of context plays in the TPACK diagram. Therefore, this book focusing on outside the USA is a helpful corrective to the inordinate emphasis on US-based contexts of educational technology research. Through this internationalization of research and work that examines TPACK in a more varied, broad, and global context, we get a better sense of how the framework plays out in practice from different perspectives. We think that this book is an important step toward that goal and that there needs to be more work of this sort that looks at TPACK in international contexts. It is essential that international educational technology research (like the studies in this book) further our understanding of TPACK in a global way, rather than a narrower, strictly American consideration of the framework.

An important question then becomes: *How do international contexts differ?* We have some understanding of contexts in the USA already, but a broader look at different TPACK contexts is useful for the future and worthwhile to examine. Going beyond western educational settings, it is important to connect these ideas globally and learn through comparisons and contrasts. The work in this book speaks to the value of a framework such as TPACK because, without a framing structure, individual studies would be difficult to connect to a larger picture in education. The framework brings these ideas together and gives us something to connect and compare/contrast between different settings and instantiations of TPACK. Thereby, we applaud the authors and editor of this book for providing research in another set of contexts that adds substantially to the *big picture* of TPACK and educational technology.

That said, we would be remiss if we did not offer observations or critique that could add even more to the body of work going forward. So, one criticism of the book could be the lack of contextual information provided in each chapter. Providing any broader contextual information about educational technology or e-learning could be a useful way to lay the groundwork. For example, the size of the e-learning markets in ten Asian countries was the central focus of a recent report (Bashar & Khan, 2007). Korea, China, and Singapore were the three largest markets in 2002; and Taiwan was ranked sixth. Though Taiwan has a comparatively smaller market, the government there supported efforts to build the e-learning related infrastructure (e.g., educational technology availability in classrooms, Science Park for technology advancement), curriculum reform, and friendly policies for e-learning industries

(Qi, 2005). This type of information helps to set the stage for helping international readers understand the broader context.

While providing this type of national or market-based information is useful, it is also essential to include more localized contexts, such as classroom size, teacher professional development, and so on. We would argue that truly understanding TPACK (and its instantiations in specific classrooms) may require going even deeper. For instance, what are the cultural parameters within which teachers and classrooms function? What is the role of the teacher in the culture of the classroom? What is the culture overall? And how do these views and approaches to teaching relate to the use of TPACK and educational technology? These are just a few possible issues or questions that could be interesting to consider, or to include some thoughts on, as we seek to expand the borders of TPACK research.

All of this attention to context is important in order to avoid perpetuating the myth that educational contexts do not matter—a myth that has too long been a part of educational research. It is always good to deepen the understanding of context with rich, clarifying detail. Educational technology is constructed as much by wires and devices as it by social constraints and policies and politics. It is imperative that we develop a better understanding of these contextual matters. In this respect, this book is an excellent and positive step forward; and it allows us to see even more possibilities for the future of these lines of rich global research.

The TPACK framework has spread its wings and established itself in the arena of educational technology since its first public presentation in 2006. That said, this book and the chapters within it indicate that there is still much interesting work being done today and more that needs to be done in the future. In that sense, we are nowhere near the end of the journey but we are, possibly (as Churchill said in a somewhat different context), at the end of the beginning.

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