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Foreword

This foreword is designed to set the scene for this book and is based on our experience as the facilitators of the Second (2nd) PCK Summit. Through a brief reflection on that role, we hope to provide some context for the work and learning that has culminated in this book and give a real sense of the collaborative learning experience that comprised the 2nd Summit.

The 2nd PCK Summit came about as a consequence of the work conducted at the First (1st) Summit, which was held in Colorado Springs in October 2012. At that Summit, the participants (mostly in the field of science education and some from mathematics) spent a week discussing research into pedagogical content knowledge (PCK)—much of which they had conducted and led—in an effort to develop some form of consensus and shared understanding around the construct of PCK. That Summit resulted in the book *Re-examining Pedagogical Content Knowledge in Science* (Berry, Friedrichsen, & Loughran, 2015) that highlighted our learning at the Summit, but also introduced what became known as the Consensus Model (CM) of Teacher Professional Knowledge and Skill.

The success of the 1st Summit led to ongoing discussions, especially among science PCK researchers internationally, about the CM as the notion of an agreed way of viewing the construct began to resonate with others. As a consequence, in December 2016, 24 PCK researchers in science education met in Leiden to continue the discussion about PCK and to push our learning further; hence, the 2nd PCK Summit was born.

Some of the participants of the 1st Summit were in attendance at the 2nd Summit, but there were also a number of new active PCK researchers and thinkers in attendance. The focus of the 2nd PCK Summit was largely on data and analysis. In so doing, it offered an opportunity for participants to tease out the intricacies of collecting data through a variety of instruments, and to seriously examine approaches and techniques of analysis in identifying, capturing and portraying science PCK. Participants were asked to write ‘outlines’ of their current PCK research in science education, and these outlines were shared and read by all prior to the Summit. As the outlines focused on data collection and analysis, they offered

a deep dive into instruments, processes, practices and procedures used in identifying aspects of science PCK.

The programme for the Summit was designed in such a way as to allow participants to work in small groups interested and/or experienced in the use of similar data collection instruments and analytic processes. This arrangement fostered in-depth discussion that was often focused on a specific task set by the Summit facilitators, such as which aspect/s of PCK does a particular instrument best articulate, or what criteria might best be used for identifying PCK using a given instrument? The small group discussions were reported back to the whole group in a variety of ways with the purpose of generating further discussion designed to challenge our thinking and generate questions to help us make meaningful progress in better understanding and portraying science PCK.

As the facilitators of the Summit, our role was to keep the learning moving forward, to not let things get too bogged down and to ensure that contributions were fully worked through at each level (small group and whole group) in order to build an agenda for ongoing development and understanding of PCK. Sometimes this role meant participating in a small group, sometimes it meant sitting back and observing, and at other times it meant offering a thought-provoking or challenging question. We were privileged to be able to participate in this way as it allowed us to use our observations to better facilitate the whole group discussions; the pedagogical purpose is to use the emerging learning to shape and reshape upcoming activities while still keeping an eye on the big picture.

Participant engagement across the activities helped to build a real sense of common purpose and, as this book illustrates, led to new insights and shared understandings of PCK in science education. It was a most demanding and enjoyable experience, and we were certainly very grateful for the opportunity to be involved and work with such a fine team of scholars.

As the Summit progressed, it was clear to all of us that that the workshops offered challenges and opportunities to move well beyond our individual ideas and views. The small group sessions created powerful agendas for the whole group and ideas started to come together in ways that led to a common expectation of conceptual coherence as a concrete outcome. As the Summit progressed, Julie Gess-Newsome helped to bring that coherence to our work by inviting us to revisit the CM from the 1st Summit. She offered her insights into the model and her observations about how it had been taken up in science education research and interpreted by others in the years since that Summit. Not surprisingly, it quickly became apparent that the model was rich with opportunity for us, as a group, to bring together our ideas and all our learning through the 2nd Summit in order to revisit and refine the CM. On the last day of the Summit, guided by Janet Carlson and Kirsten Daehler, the group refined the CM in a highly engaging and constructive whole group session. This book introduces the Refined Consensus Model (RCM) of science PCK and begins to unpack the possibilities it offers for the further development of PCK research.

Both of the PCK Summits have been invaluable experiences for all involved. They have enriched the work of many PCK researchers through the opportunity to publicly interrogate their work and to do so in a research community with a common interest and concern. This book captures the progress made during the 2nd Summit, introduces the RCM of PCK in science and invites all PCK researchers to become part of the conversation.

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Reference

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Preface

Background

Lee Shulman introduced the construct of pedagogical content knowledge (PCK) into the literature in the mid-1980s largely via articles in journals such as the Education Researcher (e.g. Shulman, 1987). Through PCK Shulman sought to acknowledge and represent a specialised form of professional knowledge, possessed by teachers, that sets teachers aside from other professionals. This knowledge typically grows with classroom experience and underpins how effective teachers are able to teach their subject matter in ways that support student understanding. The idea of a specialised form of professional knowledge crucial to expertise in teaching resonated well with academics, so PCK was quickly explored, adopted and adapted in a diversity of ways by researchers in the field across different domains, particularly in science and mathematics. Many researchers went on to focus on understanding of how such knowledge develops and how its development might be successfully supported. The first major book about PCK was the Gess-Newsome and Lederman (1999) publication *Examining Pedagogical Content Knowledge* (Springer). Not surprisingly perhaps, the burgeoning research produced a plethora of interpretations and uses of the original concept, which became problematic as inconsistencies and/or vague applications of the PCK concept began to emerge in the literature. In a review of PCK research, largely in the science education field, Abell (2007) identified this problem and she urged researchers 'to use PCK more explicitly and coherently to frame their studies' (p. 1407) to bring greater clarity and rigour into the research around PCK. However, to achieve clear and consistent practice, science and mathematics education researchers realised they first needed consensus in the field about the very meaning and understanding of the PCK construct itself.

The First PCK Summit

In 2012, the challenge to revisit PCK was taken up by more than 30 lead researchers (mostly in science education and some from mathematics education) from five different continents. They gathered as a forum to share their work and discuss issues and challenges in PCK research and the implications for policy and practice. In a week-long workshop, known as 'the PCK Summit', the researchers grappled with three broad questions:

(1) What are the attributes of PCK?
(2) What are the tools for measurement and analysis of PCK?
(3) What are, and how can we explain, the complementary and contradictory nature of research results of PCK?

Among the many outcomes of the Summit was a 'consensus model' (CM) of PCK. This generic model featuring PCK within teachers' wider professional knowledge and other outcomes of the Summit were presented at a range of (inter)national research conferences and in the spring of 2015, the book *Re-examining Pedagogical Content Knowledge* (Berry, Friedrichsen, & Loughran, 2015) was published by Routledge. This book showcased the work of the PCK Summit at Colorado in 2012 and comprised 17 chapters written by Summit participants. The book was well received, particularly in the science education PCK community, and the CM quickly became part of the international rhetoric in science education PCK research and a potential conceptual framework for research agendas in science teacher education.

By early 2016 though, it became evident within the science teacher education research community that PCK researchers—including those who participated in the Summit—were appearing to interpret and operationalise the CM differently. For example, many variants of PCK (such as dynamic PCK, canonical PCK, static PCK, enacted PCK, PCK-in-action, topic-specific PCK and domain PCK to name a few) were still being cited, along with various components of PCK. Consequently, PCK in science education continued to be assessed in very diverse ways, including the use of a wide range of instruments that attempted to measure or capture PCK, which in turn generated different kinds of qualitative and quantitative data. In part, these differences could be attributed to different goals of the researchers. Some science education studies, for example, aimed to describe the content and structure of PCK in a specific context, whereas other studies sought to assess the quality of science teachers' PCK, often times in relation to other variables. So once again, an international group of lead researchers in PCK (comprised of many from the first PCK Summit) gathered in 2016 to address these different and sometimes implicit interpretations and operationalisations of PCK, centring this time on science education for pragmatic reasons related to common purpose and focus, in a second PCK Summit that was organised as a Lorentz Workshop@Snellius in Leiden.

The Second PCK Summit in Science Teacher Education

Through invitation the organisers of the Second (2nd) PCK Summit brought together 24 researchers to attend the Lorentz Workshop. The group members, including the organising committee, were invited on the basis of their expertise and strength (both proven and potential) as researchers in the science education PCK field, their particular specialised contributions to the international research literature on science education PCK and their availability. As a result, researchers came to the 2nd Summit having used a variety of research lenses and instruments to identify and capture PCK in the fields of biology, chemistry, physics and science across primary, secondary and tertiary levels of education. With over half of the 2nd Summit group comprising original Summit members, this expert composite group also brought the advantages of continuity in thinking combined with the 'fresh eyes' of newcomers to the evaluation of progress in the field. In the workshop, the researchers were asked to revisit: the roots of their work; the data they had collected; the instruments used to collect these data; and the procedures used to infer PCK in science education from these data. The strengths and weaknesses of different instruments and procedures of data collection and analysis were discussed, and the potential of multimethod study designs were considered, in relation to the purposes of studying PCK in science education. As different kinds of instruments and their associated data were presented and discussed, participants gained insight into each other's data (and data analysis) and arrived at a more shared understanding of PCK in science education. Out of these discussions also evolved a more honed understanding of PCK in science education, enabling the group at the end of the 2nd Summit to arrive at a refined definition of PCK in the form of a refined consensus model of PCK in science education.

This Book

This current book reports the findings of the researchers participating in the 2nd PCK Summit in 2016 as they pursue the ideas and research agendas that have developed rapidly and enthusiastically out of that first 2012 PCK Summit in the science education field. It contains an evaluation of the consensus PCK model from the First (1st) PCK Summit and introduces the new model, known as the Refined Consensus Model (RCM) of PCK in science education as a refinement of the earlier model. Our book seeks not only to introduce the RCM but also to clarify and demonstrate its use in research and teacher education and practice. After an initial chapter that provides a rationale for the new model via a literature review of PCK research in science education over the last decade, a whole chapter is dedicated to the RCM, where it is presented in diagrammatic form and explanatory text. We strongly recommend that all readers of the book take extra time to carefully read and digest this second chapter before reading any of the following chapters,

i.e. Chaps. 3–14. Familiarity with the RCM will allow readers to more fully appreciate the research work of contributing authors to this book. Subsequent chapters show how this new consensus model of PCK in science education is strongly connected with empirical data of varying nature, contains a tailored language to describe the nature of PCK in science education, and can be used as a framework for illuminating past studies and informing the design of future PCK studies in science education. Specifically the book informs and enhances our knowledge of science teachers' professional knowledge (especially important in these times when standards and other measures are being used to 'define' the knowledge, skills and abilities of teachers); illustrates how the PCK research agenda in science education can make a difference to science teachers' practice and students' learning of science; and makes research and knowledge about the construct more useable and applicable to the work of teachers through the RCM. It arguably contains the most relevant, recent and internationally strong collection of studies on PCK in science education available. While this book is available only three years out from the last major PCK publication, we believe it will have great appeal for researchers and science educators alike as the need and interest in deepening understanding of PCK gathers momentum internationally. As PCK grows as an attractive field of research across the globe, this book is positioned to offer an up-to-date, international perspective on the evolving nature of PCK in science education, how it is shaping the science education research agenda and how it can inform science teaching and learning.

Finally, this book is not a restatement of what already exists; it is about the ways in which the PCK construct in science education is being better understood, used and measured. It provides leverage for advancing future PCK research in science education by: repositioning PCK within teachers' professional knowledge (as depicted in the RCM of PCK in science education); providing a shared language of PCK in science education; and showcasing new methodologies for more effectively capturing, measuring and representing aspects of PCK for science teaching.

We hope you enjoy reading this book as much as we all enjoyed conceiving and writing it!

(The Editorial team was given the honour of compiling this book on behalf of our colleagues participating in the 2nd PCK Summit.)

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Amanda Berry, RMIT, Australia
Andreas Borowski, University of Potsdam, Germany
Janet Carlson, Stanford University, USA

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