were orientations to teaching science that shaped and were shaped by knowledge of science curricula, knowledge of students' understanding of science, knowledge of instructional strategies, and knowledge of assessment of scientific literacy. Other researchers used variations of this model or constructed their own. Instruments were then designed to capture or measure PCK and explore the relationships between PCK and other knowledge bases, classroom practice, and/or student outcomes.

As the research base developed, the divergence in definitions, models, and data collection methods revealed critical differences in the thinking surrounding PCK. For instance: Does PCK exist at the level of science, physics, or force and motion? What is the relationship of teaching orientations to PCK? Does PCK exist as a knowledge base or is it a skill, or both? Is PCK an attribute of a teacher or knowledge held by the community? Can PCK be measured separately from the act of teaching? These questions and others stimulated the need for a focused and extended conversation about PCK and led to the PCK Summit.

The PCK Summit

The PCK Summit (see Chapter 2) brought together 22 science educators from 11 research teams and 7 countries to spend five days together in a retreat setting to examine the construct of PCK. Participants were active PCK researchers recognized as having differing views on PCK. In preparation for the Summit, research teams prepared syntheses of their research using a standardized format that fostered the ability to compare research programs. Through this process, participants were asked to explicitly describe the nature of PCK, their model of PCK and its relationship to other professional knowledge bases, the grain-size of PCK, whether PCK is transformative or integrative (see Gess-Newsome, 1999a), and data collection instruments or tools. These descriptions and their analysis prior to the Summit helped refine questions that would frame the Summit.

Shulman launched the Summit through an informal Skype retrospective about the "notion of inventing pedagogical content knowledge" (see Chapter 1). While Shulman described the roots of PCK as cognitive theory, he also stated that PCK was posed as a "policy claim" for use as a foundation for the development of the National Board Certification of Teachers, and as an "ideological claim" to recognize teachers as professionals with a unique body of knowledge who should be treated with respect, autonomy, and compensation (Shulman, 2012). Shulman identified five weaknesses with PCK—the absence of affect, emotion, and motivation; an overemphasis on teacher thinking versus a teacher's skilled performance in the classroom; the omission of context; the omission of a teacher's vision and goals for education; and, the relationship of PCK to student outcomes.

During the Summit, participants consistently struggled to reconsider their own models of PCK and were challenged to consider the potential of identifying

a unified model for PCK or electing to identify several purposefully competing conceptions that could be used to guide future research. Over the week, small groups created and presented models of PCK, explored the relationship of PCK to other professional knowledge bases, and revealed their underlying assumptions. Recursive presentations to the larger group allowed for the evolution of ideas while assumptions were uncovered or challenged. By the last day of the Summit, a small group took the most promising ideas and shaped them into a single model for presentation to the large group, including key definitions, examples, and relationships. I had the honor of refining this thinking into the model presented in this chapter, expanding on the thinking initiated at the Summit—so it was through the contributions of all of the Summit participants that this model exists.

A model of teacher professional knowledge and skill that includes PCK

Early in our conversations, it became apparent that too many ideas were packed into PCK. Particularly troubling were the five weaknesses identified by Shulman. The model of teacher professional knowledge and skill (TPK&S) presented here is quite different from that originally presented by Magnusson et al. (1999). Many previously competing or confusing ideas have been unpacked. The model identifies the overarching role of teacher professional knowledge and situates PCK within that model, including all of the complexity of teaching and learning.

We believe that this model offers explanatory power for existing research, provides a more robust and predictive way to think about teacher knowledge and action, and allows for extant research to be situated within the model or reconceptualized based on relationships and definitions presented.

As an overview, the model of TPK&S (Figure 3.1) originates in the generic teacher professional knowledge bases (TPKB). This is the generalized professional knowledge that results from research and best practice. Knowledge from the TPKB informs and is informed by topic-specific professional knowledge (TSPK). This new category of knowledge contributes several things: (1) It makes explicit that content for teaching occurs at the topic level (i.e., force and motion) and not at the disciplinary level (i.e., physics or science); (2) this knowledge blends subject matter, pedagogy, and context; and, (3) it is recognized as public knowledge, or knowledge held by the profession, allowing it to assume a normative role. Different than the rest of the model that follows, the two knowledge bases described thus far are context free.

In the model of TPK&S, teacher affect is recognized as making a contribution to teacher knowledge, skill, and practice. These beliefs and orientations act as amplifiers or filters to teacher learning and mediate teacher actions. It is in the classroom context that we can examine PCK. Unique to this model, PCK is defined as both a knowledge base used in planning for and the delivery of topic-specific instruction in a