CHAPTER ELEVEN

SCIENCE TEACHING AND SCIENCE TEACHER EDUCATION

There is an inherent difficulty in science teaching whereby complex and abstract concepts and ideas need to be taught in ways that make them accessible and understandable for learners. As a consequence, teachers’ attempts at simplification may inadvertently reduce such subject matter to propositional forms that, sadly, foster reliance on rote learning as opposed to encouraging the development of rich and deep understandings. Paradoxically, many science teachers themselves come from that sub-set of students who successfully managed to learn science despite the difficulty and associated teaching and learning tensions within this very situation. Therefore, it is not hard to see how they may in fact actually find themselves unwittingly recreating the same situation again for their own students, all of whom are not likely to learn “just like they did”.

In considering this situation, it is important to be reminded of the different contexts in which learning about science teaching and learning takes place. There are two obvious contexts - schools and pre-service teacher preparation programs - and the teachers, teacher educators and student-teachers that work within each are important players when it comes to thinking about how one might begin to respond to the teaching and learning challenges in science education. By paying attention to these contexts, the knowledge of practice actively created in each by these participants is able to be focussed upon and create new possibilities for capturing and portraying such knowledge so that it might be better shared within the profession and ultimately, impact the nature of science teaching and learning more generally.

Therefore, in the first instance, a clear and strong focus on science teaching in schools is important. However, a field sometimes overlooked is that of teacher education where the emerging science teachers begin their more formalised education of science teaching and learning. Within this field of pre-service teacher preparation, science teacher educators are clearly crucial as they not only shape the agenda of what the science teaching and learning curriculum might comprise, but also how it is enacted, thus impacting the learning experiences of science student teachers.

The notion of PCK (and all that it entails as outlined in the previous chapters) is then an aspect of practice that needs to permeate the work of all three groups (teachers, student-teachers and teacher educators) if the paradoxical situation outlined above is to be addressed in meaningful ways. If it were to be addressed, then not only would there be a greater likelihood that quality science teaching and learning would be an outcome, but it might also be that the knowledge, skills and ability of expert science teachers might be better understood and be more highly sought and valued. It might also create a real prospect of something to aim for in one’s own professional learning (whether as a student, beginning or expert teacher/teacher educator of science).

We would argue that in teaching generally, but in science teaching in particular, paying careful attention to the notion of PCK is one way of better valuing teachers’ professional knowledge of practice while simultaneously creating an expectation for such development as integral to professional learning.

Across the fields of teaching and teacher education, explicitly linking experiences of learning science with the practice of, and knowledge about, teaching science offers access to ways of developing science teachers’ PCK and is something we believe needs to purposefully be encouraged.

UNPACKING SCIENCE TEACHING

In reflecting upon one’s own experiences of teaching and learning in science, it can sometimes be difficult to look back and see the changes in practice (and the reasons for those changes) that led to the manner in which one teaches at the present point in time. This can be difficult to do because such changes tend to be gradual and incremental. As teachers develop and refine their knowledge and skills of teaching through reflection on experience over time, the growth in their own wisdom of practice may not be recognized as being specialized and sophisticated, but rather as idiosyncratic and intensely personal. Personal perceptions of the distinction between the perceived value of the wisdom of practice are exacerbated by the fact that teaching is generally an individual and isolated experience. Further to this, as so much knowledge of teaching is tacit, it can be extremely difficult for teachers to articulate such things as: the reasons for teaching particular content in a particular way; how the context shapes those aspects of the content that are highlighted, simplified or ignored; what specific concept attainment equates with understanding a given topic and why; what comprises a teacher’s own understanding of the content; or, what influenced that learning.

Of course, being unable to articulate responses to queries such as these does not mean that answers are non-existent, rather that the nature of teaching does not overtly encourage such articulation or create a strong professional expectation for so doing. Yet, through such articulation the specialist knowledge,
skills and ability of expert science teachers becomes more obvious and, we would argue, is encapsulated in the notion of PCK. Therefore, through paying careful attention to PCK and its development and use, it is possible to focus serious attention on expertise in, and quality of, science teaching so that it may be better understood within (and outside) the profession. To illustrate the point, it can be helpful to think about PCK as:

... a continuum of models of teacher knowledge. At one extreme, PCK does not exist and teacher knowledge can be most readily explained by the intersection of three constructs: subject matter, pedagogy and context. Teaching, then, is the act of integrating knowledge across these three domains. For convenience, I will call this the Integrative model. At the other extreme, PCK is the synthesis of all knowledge needed in order to be an effective teacher. In this case, PCK is the transformation of subject matter, pedagogical, and contextual knowledge into a unique form – the only form of knowledge that impacts teaching practice. I will call this the Transformative model.

The distinctions between these two models are subtle – the integration of knowledge versus the transformation of knowledge. An analogy from chemistry may help make the distinction. When two materials are mixed together, they can form a mixture or a compound. In a mixture, the original elements remain chemically distinct, though their visual impact may imply a total integration. Regardless of the level of apparent combination, the parent ingredients in a mixture can be separated through relatively unsophisticated, physical means. In contrast, compounds are created by the addition or release of energy. Parent ingredients can no longer be easily separated and their initial properties can no longer be detected. A compound is a new substance, distinct from its original ingredients, with chemical and physical properties that distinguish it from all other materials.

When looking at models of teacher knowledge, the Integrative model is similar to that described for a mixture. Elements of knowledge from subject matter, pedagogical and context domains are called upon and melded in classroom practice. Upon reflection, the parent domains can be found in the justifications for planned and interactive classroom decisions. The Transformative model implies that these initial knowledge bases are inextricably combined into a new form of knowledge, PCK, in which the parent domain may be discovered only through complicated analysis. The resulting amalgam is more interesting and more powerful than its constituent parts. (Gess-Newcombe, 1999, pp. 10 - 11)

Clearly science teachers do not exist, forever fixed, in one place along the continuum between the Integrative and Transformative models. At different times and in different contexts, where one might reside along the continuum varies as the development of knowledge of practice ebbs and flows as a result of the myriad of teaching and learning experiences one creates and encounters. However, it seems reasonable to suggest that at any given time, the closer one is to the Transformative end of the continuum, the more the “compound” created (or still being created) will be in evidence. Yet, unpacking the “compound” to its constituent parts is not easy.

This analogy of the compound and the continuum may also offer additional reasons as to why science teachers find it so difficult to respond to probes and prompts like those briefly noted above. Yet this does not mean that things must always be that way. As our research has highlighted, with a concentration on some of these issues (prompts in the CoRe), and with the help of colleagues through shared reflection and dialogue, ways of seeing what the “compound” looks like become possible and is demonstrated through the Resource Folios (comprising the CoRe and PaP-eRs as illustrated in Chapters 4 – 9).

In striving to develop Resource Folios we found ourselves both researching and workshopping ideas of PCK with experienced science teachers. On the one hand, our research uncovered interesting issues about the nature of PCK, while on the other, it also brought to the surface a wealth of previously untapped knowledge of science teaching and learning for many of the participants with whom we were working (particularly illustrated through the vignettes and the research study that comprised chapter 10).

Through our research, it was obvious to us that science teachers appreciated the opportunity to pursue understandings of PCK as they began to recognize and respond to the various alternative approaches to enhancing students’ understanding of particular science topics and concepts. As they unpacked their own and their colleagues’ knowledge and practice of science teaching, the strength of their own professional learning was constantly being highlighted and demonstrated through their views of the nature of their expectations of teaching. Through this process of exploring science teachers’ PCK, the complexity of such knowledge as well as the rich variation that contributed to a recognition of the skills and expertise so fundamental to good science teaching and learning continually emerged.

As noted earlier, it is difficult for individual science teachers to recognize how their understanding of specific content has changed from the time they first started teaching. Yet being able to explain how one’s understanding of particular subject matter content has changed and developed offers insights into how one’s professional knowledge and practice may have been refined over time. For example, how one came to understand why a particular concept was difficult for students to grasp can be a catalyst for teaching in