WAYNE MELVILLE • DOUG JONES • TODD CAMPBELL

BUILDING THE SCIENCE DEPARTMENT

STORIES OF SUCCESS

NSTA press
National Science Teachers Association

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1840 Wilson Blvd., Arlington, VA 22201
www.nsta.org/store
For customer service inquiries, please call 800-277-5300.

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Foreword

Stories. Teachers love to tell stories of their classrooms and their practices. The stories can be about their successes, their difficulties, their triumphs, and their disasters. They can be inspiring and they can be harrowing. They can also instruct, guide, and help us learn.

In our early thinking about this book, we decided that we wanted to work with the stories of teachers who had negotiated—and continue to negotiate—the (at times) perilous paths of reform. What were their stories, and what could we, as a larger audience, learn from them? What were the contexts that supported their learning? What did they need to know, learn, and understand as they looked to challenge their practices? What activities did they engage in that helped them change their classrooms? And what were the processes by which they came to begin to understand the lofty ambitions of reform documents in terms of their own classrooms and departments? These are all important questions, as the work of teachers is at the heart of any and all reform efforts.

We were also interested in the stories of teachers at different stages in their careers, for we know that the professional learning needs of teachers are constantly evolving. The stories that new teachers tell are necessarily different from the stories told by teachers with many years of experience. The stories told by teachers who take on leadership roles, either formally as department chairs or informally as teacher leaders, are different again from those teachers who are more focused on their classrooms. Regardless of experience or leadership role, the work of becoming a teacher never ends, so we suspected that there may be some common themes running throughout the teachers' stories, regardless of career stage.

In planning to ask teachers to write of their teaching and learning, we were aware that just asking somebody to write on such an open-ended topic was bound to be met with the question "Where do I start?" Clearly we needed a framework that would provide a guide for the stories to be told but not restrict what was important to the story writer. To this end, we used the framework developed by Helen Timperley, Aaron Wilson, Heather Barrar, and Irene Fung and published in New Zealand in 2007 (available from *www.oecd.org/edu/school/48727127.pdf*).

Synthesizing research into the professional learning of teachers, the framework developed four basic components of effective professional learning opportunities for teachers:

1. Professional learning context
2. Content of the professional learning opportunities
3. Activities that promote professional learning
4. Learning processes that teachers engage in

For each of these components of professional learning, the framework identifies specific constituent areas that can have a positive impact on student learning in science. The full framework is shown in the appendix (p. 137).

Having a framework to guide writing is one thing—having teachers to work within that framework and tell their stories is quite another. To bring the framework to life, we decided to approach teachers with whom we had worked and who were committed to reforming their teaching and learning or who came to our attention by the contributions they were making to science education, both in their own schools and further afield. The teachers who agreed to work with us have taught from 4 years to more than 28 years in secondary schools in Canada and the United States. Some have worked as department chairs, and all are teacher leaders in some capacity. All are exemplary teachers committed to both their students and our profession. Working with Jason, Shawn, Liz, Mike, Steve, and Julie has been a privilege for us, and we are indebted to them for their candor and their ongoing contributions to teaching and learning. We trust that you will find their stories as insightful as we found them.

This book can be seen as comprising two parts—the first sets out an understanding of scientific activity (one of the key tenets of the current reforms in science education in North America), the rationale for concentrating on the department as a place for building and sustaining teacher professional learning, and the aforementioned professional learning framework. In Chapter 1, we begin by outlining how scientific activity can be used to frame professional learning within science departments on the grounds that one of the major roles of the science department is to accurately represent the discipline for *all of our students.* It should be noted that Chapter 1 connects the accurate representation of the discipline to the *Next Generation Science Standards* (*NGSS*). In addition, it should be noted that the *NGSS* were developed from *A Framework for K–12 Science Education* (referred to as the *Framework*). This is an essential compendium document necessary for understanding the rationale, organization, and commitments of the *NGSS.* Although not all U.S. states have adopted the *NGSS,* most have aligned their new state standards with the *Framework.* In Chapter 1, we assume that the reader has some familiarity with the *NGSS,* the *Framework,* and three-dimensional learning as the cornerstone of these documents. If you are not familiar with these documents, we recommend referring to some of the following introductory resources for supporting a beginning understanding of these foundational documents:

- "Three-Dimensional Instruction: Using a New Type of Teaching in the Science Classroom" (available from *http://static.nsta.org/files/tst1508_50.pdf)*
- "Next Generation Science Standards: What's Different, and Do They Matter?" (available from *http://stemteachingtools.org/brief/14*)
- STEM Teaching Tools (available from *http://stemteachingtools.org*)

Chapter 2 provides an understanding of the science department as it currently exists in secondary schools and the powerful influence that it has on teaching, learning, and professional development. Chapter 3 details the professional learning framework developed by Timperley et al. (2007), thus setting the stage for the second section of the book—the teachers' stories.

The second part, starting with Chapter 4, is structured so that we work through each of the components of the professional learning framework (context, content, activities, and processes) through the stories (hereafter called *vignettes*) told by our colleagues. Each chapter starts with Jason providing a brief overview of his experiences before Shawn, Liz, Mike, Steve, and Julie take turns discussing their thoughts on professional learning within the framework. The arrangement here is deliberate; the vignettes are arranged in order of experience, from beginning teacher to more experienced teachers. Following the vignettes is a commentary that highlights the key points and implications for teacher learning that emerge from the work of our colleagues. An important feature of our previous book, *Reimagining the Science Department* (NSTA Press, 2015), that we have included in this book are questions to ask yourself as both a science teacher and a teacher leader. Such questions are important because to challenge our own stories is to start to make changes that improve our practices and start to bring those practices into greater alignment with the ideals of the current reform documents.

As you start looking at and learning from the stories of other teachers, please remember to contact us if there is any way we can help you in your work.

Acknowledgments

There are several people we need to thank for helping bring this book to life. First and foremost, we must acknowledge the work of our colleagues Jason Pilot, Shawn Devin, Liz Potter-Nelson, Mike Sewards, Steve Lankin, and Julie Gaubatz. It is always a privilege to work with such talented professionals. Without them, there would be no book.

Thanks to Claire Reinburg, Rachel Ledbetter, and Donna Yudkin at NSTA Press for their ongoing support, advice, and encouragement.

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Finally, to Rosemary, Lisa, and Joy, our significant others, for always being there and keeping us grounded.

About the Authors

Wayne Melville is a professor of science education and assistant dean at Lakehead University in Thunder Bay, Ontario, Canada. He taught secondary science in Australia from 1989 to 2005, eventually becoming a department chair. During his school teaching career, he completed a master's of science and a doctorate in science education and was a national finalist for a science teaching award organized by the Australian Academy of Science. Since moving to Lakehead University in Ontario, Canada, he has published more than 70 articles in the field of science education. He has been a committed member of the National Science Teachers Association (NSTA) for many years and contributes to NSTA journals and conferences. His e-mail address is *wmelvill@lakeheadu.ca.*

Doug Jones is a science faculty member at Sir Winston Churchill Collegiate and Vocational Institute in Thunder Bay, Ontario, Canada. He has served as a science chair for 20 years of his 34-year career. Doug has taught in the Lakehead University department of education for several years and has developed several courses in science education. Doug and his department are well known in science education circles for their paradigm-shifting work in the teaching and learning of secondary science, along with significant work regarding scientific literacy, professional learning communities, assessment and evaluation, and growing one's personal professional practice. The department has also mentored more than 150 preservice teachers over the past 20 years. Doug enjoys the research and writing relationship he has with Wayne and Todd and is proud to be a contributing member of both the Science Teachers' Association of Ontario and NSTA. His e-mail address is *dougyjones@gmail.com.*

Todd Campbell is a faculty member in the Neag School of Education at the University of Connecticut. His research focuses on cultivating imaginative and equitable representations of STEM activity. This is accomplished in formal science learning environments through partnering with preservice and in-service science teachers and leaders to collaboratively focus on supporting student use of modeling as an anchoring epistemic practice to reason about events that happen in the natural world. This work extends into informal learning environments through a focus on the iterative design of informal learning spaces and equity-focused STEM identity research. Todd is a former high school and middle school science teacher and is a proud member of NSTA. He consistently contributes to NSTA journals as an author and reviewer. His e-mail address is *todd.campbell@uconn.edu.*

About Our Colleagues

This book would not have been possible without the thoughtful contributions of our colleagues, who have written of their experiences in science education.

Jason Pilot is currently the head of science at Sir Winston Churchill Collegiate and Vocational Institute in Thunder Bay, Ontario, Canada. He has taught general science, chemistry, and environmental science for 14 years. He also taught grades 4 and 5 for one year and spent two years as a secondary resource teacher for Lakehead Public Schools. As a teacher, he is always trying to bring real-world activities into the classroom, which has driven his development of problem-based learning and inquiry.

Shawn Devin is a secondary school science teacher in the Toronto Catholic District School Board. As a young and passionate teacher, now in his fourth year, he strives to foster an exciting and engaging learning environment that uses investigatory activities, cool experiments, differentiated teaching strategies, social learning, and real-life connections. He was fortunate to be awarded the Don Galbraith Preservice Teacher Award of Excellence from the Science Teachers' Association of Ontario in 2012.

Elizabeth (Liz) Potter-Nelson is a science teacher at Stevens Point Area Senior High School in Wisconsin and has taught for 11 years. Before recently returning to the classroom, she spent five years as a department chair working closely with teachers to transition their curriculum to be phenomena-driven and aligned with the *Next Generation Science Standards* (*NGSS*).

For more than 28 years, **Mike Sewards** has been a teacher of exercise physiology, general science, and chemistry in Thunder Bay, Ontario, Canada. He has been recognized provincially as producing classroom environments that encourage powerful learning and has worked on a number of Ontario Ministry of Education projects in this area. He has also nurtured many preservice teachers and has been an active member of his school's professional development team.

Steve Lankin is a chemistry and physics teacher in Thunder Bay, Ontario, Canada. Some say that he can make his subjects come alive for students with a combination of brilliant teaching strategies and humor. He believes that knowing what science should look like—in both classrooms and real-world scenarios—is fundamental to working with students, preservice teachers, and other teachers. He has taught for 18 years.

Julie Gaubatz, EdD, teaches science and chairs the science department at Hinsdale South High School in Darien, Illinois. With more than 20 years of teaching experience coupled with a background in laboratory research, she is particularly interested in models of change, inquiry, and leadership that improve students' experiences in secondary science education.

Finally, before we begin, we need to highlight an important point. Many of the teachers we have worked with have been involved in reforming their practices for many years. This means that many of the vignettes reference work that supports the teaching of science as inquiry as is emphasized in the *National Science Education Standards* (NRC 1996). Although the terminology has changed (see Bybee 2011 for a concise explanation), the importance of the vignettes lies in their power to reveal how teachers have gone about the work of change, which is necessary with *A Framework for K–12 Science Educatio*n and the *NGSS*. When our colleagues talk about "inquiry," rest assured that they are talking of evolving practices that align with the latest reform documents.

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The Content of Professional Learning

The content of professional learning opportunities is an important consideration for science teachers, but the reforms of *A Framework for K–12 Science Education* (the *Framework*) and the *Next Generation Science Standards* (*NGSS*) mean that there is a change in emphasis for that content. As Reiser (2013) states, the reforms require that teachers

> *help students continually work toward explanatory models, developing these ideas from evidence. This focus … challenges … teachers in how to motivate lessons through phenomena that need to be explained, how to help learners develop these explanations, and tie them to the phenomena and questions that motivated them. (p. 4)*

What does this changing emphasis look like in departments that have been active in reforming teaching and learning? In Jason's experience:

> *Over two years we invested a lot of time and energy into redefining what learning looks like in our classrooms. We focused on learning goals, established what it meant for students to be successful, and what types of feedback we should give our students. For many teachers it was a quantum leap from where they were already teaching.*

In this chapter, our colleagues highlight how their relationship with content is evolving in response to the new and exciting challenges connected to recent reform. In considering their vignettes, we can see how that evolution changes over the course of a career.

A "STUDENT OF SCIENCE AND OF EDUCATION"

Shawn

Just as our current and future students learn from us, we must continue to evolve our own teaching and learning; one of the bases for this evolution is the information we learn and how it can be applied. In this vignette, I would like to address the content that has been conducive to my own professional learning and explain how this content has allowed me to extend my pedagogical knowledge.

The Disciplinary Knowledge of Science

Scientific content knowledge—or disciplinary core ideas—is an essential component of our teaching. As a young teacher of science, I have come to appreciate the grasp of knowledge I have and also be humbled by the knowledge I have not yet grasped as thoroughly as I'd like. This acknowledgment emphasizes the need to learn and incorporate new knowledge into my repertoire, in turn broadening students' understanding of scientific ideas and the practices of science. A strong and broad understanding of science allows me to engage directly with students in understanding more refined ideas. Most of us are specialists in at least one branch of science; however, increasing our knowledge across all sciences can prove to be useful when helping students make the connections between the major concepts of the disciplines and the knowledge expectations of the curriculum.

My professional learning of content knowledge has been an essential component to improving and expanding my existing teaching strategies. As students and teachers of science, our increasing knowledge can, in many respects, be gradually incorporated into our existing materials and teaching methods. A richer understanding of the practices of science also allows us to reconsider aspects of our teaching strategies. Understandably, this may increase the demands on teachers to further their knowledge in certain fields of science, even in the context of many teachers' family commitments, extracurriculars, or other time restrictions. However, from what I have experienced in my career so far, even the smallest pieces of knowledge we acquire can enhance our ability to support students in understanding concepts or disciplinary core ideas in science.

Considering How Students Learn

To teach content, we must be attentive to how our students learn, how we communicate concepts or ideas, and how we assess learning. The basics of my awareness of these ideas came directly from my teacher education training; teaching science from reformed perspectives and assessment strategies was an area I was familiar with but not practically experienced in before I obtained my bachelor's degree in education. Although earning this degree meant learning a combination of theoretical and practical applications, the emphasis was more on pedagogy. As my career has developed, there has been a shift from this emphasis to a more practical style of professional learning. Although additional qualification courses and workshops are an excellent source of information about student learning and assessment, I have found so far that colleagues and students are the best source of information in these areas. Who better to ask than the students who are learning from your teaching! Of course, the underlying pedagogy and theory must still be emphasized when taking colleagues' and students' opinions into account, but the prior experience of colleagues and the direct experience of students provide an excellent account of your teaching, especially in terms of how it can be modified to best accommodate student learning and how this learning is assessed.

Integrating Practice and Theory

Just as we can listen and learn from students and colleagues about how students learn, we may never discover if these ideas hold true if we do not desire to experiment with them. The majority of professional development workshops I have attended so far have provided theory on how best to approach different subjects and specific topics within those subjects; these ideas are always supported with practical exercises. These workshops, usually carried out by experienced teachers, have been incredibly informative and useful! I must stress from previous experience that a balance of theory and practice is critical in our growth as effective science educators. However, a question may arise from this statement: Does this balance lie more toward theory or practice? Unfortunately, this is not a black-and-white question; I can say, however, that a balance should be established that works best for the students you have! And that balance is always going to be shifting as you gain more experience.

One of the most important ideas I adhere to is that we will always be students of science and of education no matter how experienced we become; there is always something to learn from both disciplines. As educators, we work with students, teachers, administrators, and parents to assist with student aspirations and accomplishments of learning and life goals. Similarly, we must aspire to learn and strive to further our own expertise as science educators. These aspirations come in light of the disciplines that we love; from my own experience, the content most conducive to my professional development comes directly from the colleagues and students I work with and from my motivation and drive to acquire knowledge. Students and colleagues have proven to be some of the most valuable resources for expanding my foundation in teaching the content and practices of science in understanding how students learn and how to integrate the theoretical and practical aspects of teaching. There will always be great students and teachers to learn from, and I also believe that I will be a lifelong learner in education and science; as a result, I can safely say that my professional learning will continue indefinitely!

EXPERIENCE THE MATERIAL

Liz

Throughout my experience as an educator and leader, I have participated in a considerable number of professional learning experiences. Some of these have been outstanding, whereas others have left a lot to be desired. When I reflect on these experiences, I find that authentic and discipline-specific professional learning, which forces me to experience the material in a similar manner to which I will use it in the classroom, has been the most beneficial.

Modeling Authentic Engagement

Shortly after the *NGSS* were released to the public but before my state had adopted them, a local university offered a summer course called "Teaching K–12 Science With the *NGSS.*" I jumped at the chance to take this course for a number of different reasons. The *Framework* had been out for some time and although I knew it was important to read this prior to beginning work with the *NGSS,* I struggled to find the time to make it a priority during the school year. In addition, I knew that in my role as a department chair I would need to have a greater understanding of the *NGSS.* I would not only need to know about my area of expertise; I would need to know about additional disciplinary core ideas and their corresponding performance expectations, both within and leading into high school. This course seemed like the perfect exposure and—more importantly for me—I would be forced to make the time to look at both the *Framework* and the *NGSS.*

Although I expected the course to review the *Framework* and the *NGSS* from a K–12 perspective, I did not expect the course to engage us (teachers) as learners in ways that represented how the standards documents envisioned us engaging with students. I assumed that we would be participating in a book study—reading, discussing, and reading some more. Although there was reading, the course exemplified best practices in science education; instead of lecture, we were drawn into discussions and experiences that highlighted the intricacies of the *NGSS.* We held in-depth discussions about modeling and what made an effective model. We tried to explain how smells moved around the room. We looked at syringes and tried to model what happened to the air molecules when we compressed the plunger. We discussed phenomena and why they are compelling and necessary when designing lessons. We discussed how phenomena could drive a lesson and how student-generated questions about the phenomena could lead to experiences that would help students learn not only content but also scientific practices and skills. Finally, we put everything that we learned into practice and tried to write a unit of instruction, anchored by phenomena and supported by questions and subsequent experiences.

This experience was enriching, eye-opening, frustrating, and, most importantly, engaging. I was forced to work with the *Framework* and the *NGSS* in a manner that ultimately gave me a greater understanding of their complexities. I was also provided with experiences that I could bring back to teachers within the science department and students in the classroom. Through this experience, I gained confidence in working with the *Framework* and the *NGSS* that I would not have gained had someone just told me what I needed to know.

Using Past Experiences

Participating in authentic and discipline-specific professional learning that models classroom instruction is something that I had completed earlier in my teaching career as my district transitioned to the Physics First model of teaching. Going to Physics First was a huge curricular shift for us as a team, and for many it was a huge pedagogical shift as well. Although labs existed in our courses, there were not many, and those that did exist were cookbook in nature, which would need to change with Physics First. In addition to shifting pedagogy, we were also going to need to place teachers into areas that they were not necessarily comfortable teaching. For the first few years, we would need a number of different teachers to teach outside their content areas as our students worked their way into our new normal. We had enough teachers who were certified to teach physics; however, their backgrounds were in other content areas.

In working to get the entire department to a similar understanding of the pedagogy and content with regard to these changes in physics, every science teacher in the district was supported to attend a weeklong training about the philosophy of Physics First. During this training, we worked through labs as if we were students. We set up equipment, looked at data, compared results, had discussions, and were given the confidence to go into a school year with a new series of courses. When we modified our chemistry curriculum the following year, our chemistry teachers already knew the physics curriculum thanks, in part, to this professional learning experience. Participating in the program and knowing how our students were learning physics gave our chemistry team a strong foundation from which to build the chemistry curriculum.

Having been through a large curricular change and looking forward to a similar change with the implementation of the *NGSS,* we are looking to provide a similar professional learning experience for teachers. We brought in experts who have provided our teachers with authentic and discipline-specific learning experiences that exemplify the *NGSS.* We are sending teachers to conferences and professional development workshops where they can work with the *NGSS* and the *Framework.* We are providing teachers with time to understand the intricacies of a shifting pedagogical approach to science. Teachers have embraced the deliberate introduction to the *NGSS*, having seen the positive effects of successful professional learning in their classrooms not too long ago.

THIS LOOKS VERY DIFFERENT FOR ME TODAY

Mike

As I was cleaning up and organizing files and exemplars at the end of the last term, I came across some student inquiry products from more than 10 years ago. I thought to myself that I was holding some pretty good work but that today, in many respects, it didn't cut the mustard in terms of my current understanding of how to develop the process, product, and communicative skills about inquiry in the students—and their ability to apply that learning to producing a superior product.

Reform as Content

In my opinion, curriculum reform has been evolving from a time when importance was placed on what units will be in a course and the content that will be taught in those units to asking how students learn and how they can take control of their learning to maximize success. Beginning in grade 9, our department engages students with an accurate representation of science. Starting early gives us time to address the knowledge and practices in each unit and connect the two together as our students move through high school.

When you start teaching science with grade 9, you're teaching it in pieces, and often we have to relearn these pieces. Actually teaching what goes into a scientific report, helping students understand why that report is being written, and teaching students how to write is pretty daunting. If you can do that in little pieces, without them even realizing that they're writing a report, success follows. I have a lot of really cool things now developed as little pieces: how to teach students to develop a data set; how to teach students to write up an introduction to a lab; how to teach research; how to teach students to write a discussion, conclusions, and a hypothesis—all these are little pieces. I'm getting better now at putting those pieces together after 15 years of experience, learning from my mistakes, and reflecting with my colleagues. I also now share these things with younger teachers.

Focusing on Assessment and Evaluation

Although the heart of my professional development lies with the department, external expertise can have a significant impact. One initiative from the Ontario Ministry of Education and my board was professional learning in assessment and evaluation (A&E). The A&E initiative, combined with our work on inquiry, opened my eyes to the idea that assessment can be multifaceted, varied, and ongoing. That has had a major, ongoing impact on my practice, which is really something, considering that I'm in the last quarter of my teaching career. The major impact has been in terms of student success and my planning and delivery of lessons and assessments. As I worked with teachers and students, the initiative developed my ability to identify and communicate the success criteria necessary to guide the production of high-quality work and products.

Initially I was skeptical going into the work—"OK, here we go again." I was busy and remember being told that I was going to be on the A&E team. That probably ended up being the best thing for me, and my teaching, that I've done in years. It was exciting to have that happen toward the end of my career. One of the biggest impacts was my realization of how A&E can be used to support and strengthen a more accurate representation of science in the classroom. This was made clear by our professional development trainer from the Ministry of Education. He would tell our team that all of us learn best when we're doing and that we get better at it with practice. If I'm up in the front teaching, then I'm the one who's "doing science," and they're sitting there listening but not "doing science." We try to engage with our students as much as we can and have them carry out the little pieces of what we're teaching them. That's what makes the strategy different from being "hands on." For example, having students get together in a group and brainstorm several variables that you think might affect "the breathing rate of a fish" and then report back and discuss that with the class means that they are "doing science" rather than me telling them—the latter of which allows them to opt out of the thinking and learning. It's motivational, too, because the students are directing the conversation and engaging with scientific ideas and practices.

Learning and practicing more discipline-appropriate A&E strategies means that I can meaningfully assess a student's ability to communicate, observe, use critical thinking skills and understanding, self-assess, peer-assess, and give feedback. It's no longer just about performance on a test, exam, or product. All of this evidence allows me to sit back, reflect, and use the term *professional judgment* in a relevant way to come up with a final mark. It's now been a while since I have used software like Marks Manager as an accounting tool to crunch only the product or test data and come up with a student's average. For me now, if a student is sitting with a classmate having a conversation that is helping that other student come to a good understanding about a scientific idea or practice, then I have evidence that the student tutoring has mastered that scientific idea or practice. If I have another student who has developed a simple class resource package on how to negotiate Excel to generate a scatter plot, then I have evidence of his or her ability to graph as a sensemaking practice and am not limited by a small mistake that the student might make on a graphing test that ends up having a large impact on the overall mark.

The new knowledge I have about A&E has dovetailed with my inquiry understandings to increase student success. It all comes down to the question "What does a really good representation of science look like?" That's what I had to understand before I could improve my practice. Once you get that, you can also get at what constitutes success in each of the little pieces and how you assess and/or evaluate them. Once the students know what it is that they're attempting to do, they can start to coach each other. They should all have an understanding of what each of those little pieces should look like. In the real world, as in school, a lot of effective inquiry is done in teams. They'll divvy up the jobs and get to work. Back in the day, students would just put together the report they thought the teacher wanted, staple it, and hand it in. This looks very different for me today.

I'M A BIT OF A DINOSAUR, BUT I'VE LEARNED

Steve

Process is a big deal for me—not only those processes students go through to understand how science is carried out, but the processes that students use to manage their learning in the first place.

Colleagues Leading on Assessment

One of the major professional learning initiatives for our department has been the Ontario Ministry of Education's work on A&E, which Mike has already talked about. I wasn't selected to be part of the teacher teams, but because our department meetings provided opportunities for those who were involved to report back and discuss what they had learned, I was able to understand what was being conveyed and start to make changes to my practice. I think it's great that we have that communication. That's where I learned the content of the reform from, and then I followed up by talking to Mike on the side. Depending on the department, I believe it may not be necessary to take training sessions. If you've got a good, collegial department, the support structures, and teachers that are interested, then you have everybody on board and they're going to put in the effort. I think our department's been very, very good like that.

With the reforms to assessment, my initial thought was that this was a wonderful thing, especially as it allowed us to assess the practices of science across our subjects. So let's bring it into our classrooms and make the move from a predominance of summative assessments to a wide variety of formative assessments. I know that in my classes I never used to do that (formative assessment) too much, but I have started to do more over the last six years. Although the reform focused on assessment, in practice it also means working with students to get them to help each other, especially with descriptive feedback practices. It's important that these types of assessment take place before any testing or other summative practice. Students could have been working on an important assessment for a month and been totally lost. They hand in something that is unrelated to what you asked them to do. It's much more powerful for me and my students, when introducing practices such as argumentation, to do two formative assessments that don't end up getting a mark. Instead, there's an interview where I can give them descriptive feedback on where the work is headed and where questions can be clarified for both the students and myself. I'm a bit of a dinosaur, but I've learned.

AN APPRECIATION OF BOTH REAL SCIENCE *AND* REAL TEACHING

Julie

Learning styles were a cornerstone of teacher education when I began my teacher training in the mid-1990s. My previous academic pursuits had focused on scientific research, and my naïve mindset was that my own preferred way of learning worked really well. Discovering information about different learning styles and personality traits was one of the first times it struck me that not everyone liked the same approaches to learning that I did, and that my job as a teacher was not to change how students best learned but to work with these differences to help all students engage with and integrate new learning experiences. Although learning styles–based approaches have since come under increasing scrutiny (e.g., Pashler et al. 2008), understanding the diversity of learners' personalities was an important event for me as I moved from being surrounded by research-lab scientists to working with students and colleagues in K–12 educational systems.

The Unique Needs of Those Involved

Occasionally, when I work with teachers in other schools, my mindset can temporarily slip back into assuming that my audience enjoys the same approaches to learning as I do. Experience, however, has taught me that my consultations are most effective when I cater to a wider range of participants' proclivities. For instance, although most teachers in my own department enjoy learning about the underlying theory and empirical research base of a new educational method, other audiences may find the theory and research less important to their implementation of the work itself. Similarly, some audiences respond positively when I use more experiential learning strategies during professional development programs, whereas others prefer that I simply "get to the information." Appreciating audiences' varying comfort levels with different forms of presentation reinforces my understanding that my reflections on my own professional development preferences are bounded by my own experiences; therefore, what works for me and the teachers I interact with may not be the right approach for all science teachers.

Presenters are usually passionate about their subjects. Such passion often reveals a well-rounded understanding of a topic but other times can be experienced by attendees as a zeal that alienates other perspectives. From my experience as a teacher and educational leader, professional development must allow room for teachers' creativity, educational philosophies, and judgment of their students' interests and needs. Presenters are most effective when they understand that in order for teachers to embrace a new idea for their classrooms, they must be convinced of its likely effectiveness and its suitability for their idiomatic teaching approaches.

One of the many laudable aspects of teaching is that there is no "one" right way to do it; although there are globally effective strategies, sometimes what works for one teacher may not work for another. I think this is reflected in how teachers integrate reforms into their curriculum. There is a risk with dogmatic presentations on reform, which, although impassioned and possibly persuasive, can imply a lack of respect for the audience's knowledge and professionalism. For some audiences, this may be fine, but for others, a one-size-only approach to reform might ferment resistance where it doesn't need to be. When reforms are presented as flexible and adjustable approaches to science education, this lets them jive with current curricula, teacher skills, and student needs—it allows teachers to more easily see how the reform could work for them and their students.

The Content Is Most Important

I frequently attend workshops and conferences with teachers from my department, often seeking sessions on approaches to the teaching and assessment of the practices of science. Our comfort with the presenters' approach to professional development is important, but it is the content of their presentations that most influences us. Content that moves us toward implementing the practices and their assessment in our own classrooms usually involves instruction that includes an appreciation of both real science and real teaching. It also involves an openness to teachers adapting reformed ideas that match their comfort levels as well as their students' interests and needs.

Coupling an adaptable approach to the practices of science with a strong understanding of the nature of science increases the effectiveness of professional development offerings. Understanding science content fully and deeply, making the connections from one content area to another, seeing the possible lines of investigation: This level of engagement in science is what we want for our students, but it is also what we want for ourselves. Immersing ourselves in science content gives us the flexible foundation that broadens our conceptualization of science and expands how we can portray and explore the practices of science in our classrooms. Having a strong and continually reinforced science content base increases our ability to create lessons and laboratory experiences for our students and helps us problem solve as we inquire side by side with our students. Science content helps scientists as they conduct experiments, and it helps teachers as they create experiences that convey scientific ideas and processes to their students.

Grounded in Classroom Implementation

The final ingredient that I think increases the effectiveness of a presentation on reforms is an understanding of the real-world classroom. One of the most frustrating experiences for my teachers is sitting through a presentation by someone who has an intriguing idea that would be interesting to consider in an idealized world but that appears unworkable within the constraints of a normal classroom setting. Presenters who are aware of teachers' day-to-day work are also likely to understand that teachers lack the flexibility or the control to cut massive amounts of content from their curriculum. Reform projects that require six weeks to complete might work if they are carefully crafted to integrate with required course content; however, if they simply add six extra weeks of classwork, then teachers will struggle (or, more accurately, won't bother) to identify which of their existing lessons and activities to correspondingly remove.

This is especially true if teachers work on a team in which a single teacher has to persuade team members to try something new. If new instructional and assessment strategies fit with the team's philosophies and do not require the removal of key units of work that are valued by the team, then the task is not as difficult as it would be to persuade a team to cut an entire unit. Practices that can be incorporated into teachers' existing curricula have a much better chance of success than reform that requires a large, immediate curricular overhaul. The beauty of incorporating reforms into the curriculum in "half-steps" is that as teachers experience success and attempt more small moves toward the ideal of the reform, these steps can accrue into substantial change over time.

Reflecting on how professional development best enhances teachers' growth and subsequent teaching, I think that the fit between the participants and the presentation is key. "Knowing their audience," effective presenters not only accommodate teachers' prior knowledge, confidence levels, and motivations but also listen sensitively to understand teachers' school structures and the needs of their specific student populations. I also think teachers are most receptive to content when it is presented with an openness to incremental adaptations. Finally, for my own department, professional development that affirms both of the fields we are immersed in—education and science—is critical. Science teachers like science—actually, we love science. The ongoing question that we work to answer through our experiences and our continued professional development is how we can best get students in our classrooms to understand, use, and love science, too.

Commentary on the Content of Professional Learning

If it ever was, science teaching can no longer be about the presentation of decontextualized, immutable "facts." The reforms of the past two decades have consistently stressed the need for teachers to develop classrooms in which students work to shape ideas from evidence that explain the *why* and *how* of natural phenomena. As a result, the content of professional learning opportunities must be more than disciplinary knowledge; it must also include how to use that knowledge in a way that reflects the human construct that is science. Each of our colleagues' vignettes reflects this wider understanding of content: a broader and deeper understanding of disciplinary knowledge (from science and education), the integration of theory and practice, and an understanding of how students learn.

Broader and Deeper Disciplinary Knowledge

Regardless of their years teaching, all of our colleagues spoke of a need to learn more about both science and education. In science, there was a need to learn disciplinary knowledge, not just in the specific topic area but also across the discipline and the practices that bind the topics together. This learning was not restricted to just the latest developments in the discipline but instead led to a richer understanding of the discipline and how it came to be. In education, there was a recognition of needing to learn how students learn, how to assess student work, and how to develop credible teaching strategies for the learning required by the reforms. As Shawn said, teachers need to simultaneously be "students of science and of education, no matter how experienced we become."

Science content knowledge is the foundation on which our work is based. Usually educated and certified as specialists in particular science topics, we are often called on to teach across the discipline. This can be daunting for beginning teachers, as it leaves us more confident in some topics than others. Having a "strong and broad understanding of science" allowed Shawn "to engage directly with students in understanding more refined scientific ideas." Developing our content knowledge builds confidence across and between topics, "helping students make the connections between major concepts and the knowledge expectations of the curriculum." For Mike, there was a desire to work as a department to "address the knowledge and practices in each unit and connect the two together as our students move through high school." Steve believed that the changes in assessment were beneficial in developing the practices of science across the topics that he taught. Julie, with an equal wealth of experience, reiterated the same point. For her, making connections between topics gives teachers and students the opportunity to develop "possible lines of investigation" and build the level of engagement in science that "we want for our students [but also] what we want for ourselves." As a teacher and chair, Liz expanded on the importance of content knowledge in her own specialization and "additional disciplinary core ideas" to the need to be aware of what to expect from students coming into high school science from elementary schools. This is an essential point, as reform documents such as the *Framework* and the *NGSS* discuss science education being a continuum from K to 12, and we ignore that continuum at our own risk. Education is a continuum, and teachers need to be cognizant of the knowledge students are bringing into the classroom. The disciplinary core ideas are also central to the other side of content knowledge—the practices that shape the scientific enterprise.

For Julie, content must be seen in its broadest sense: "Science content gives us the flexible foundation that broadens our conceptualization of science and expands how we can portray and explore the practices of science in our classrooms." The building of a "flexible foundation" can also act as a motivator for challenging existing teaching practices, as Shawn noted: "A richer understanding of the practices of science also allows us to reconsider aspects of our teaching strategies." Mike spoke of teaching in "pieces" and helping students understand—and have opportunities to practice—those pieces. By understanding the "pieces" himself, Mike was then in a position to help his students understand what success in "each of those little pieces should look like." By teaching science content and practices as "little pieces," Mike has moved his students beyond the point where "students would just put together the report they thought the teacher wanted, staple it, and hand it in." Similarly, Steve used the assessment reforms to help his students improve their understanding of the practices of science. Rather than allowing students to be "totally lost," the use of formative assessments allows for the provision of "descriptive feedback on where the work is headed and questions [that] can be clarified for both the students and [teachers]."

Understanding and constantly reinforcing the practices of science allows teachers to move beyond the transmission of science "facts" to the ability to "create lessons and laboratory experiences for our students and [to] problem solve as we inquire side by side with our students." In this nutshell, Julie has encapsulated the reforms promoted by the *Framework* and the *NGSS.*

Although we may pursue a broader and deeper understanding of science, we also need to move toward a greater alignment of our teaching practices toward the ideals of the reform documents. This means constantly evolving our understanding of teaching and learning. Even in the early stages of his career, Shawn was already noticing changes in how he was approaching the task of learning more about education. Moving away from the focus on pedagogy in his teacher education program, he was now focusing his learning on the areas of greatest importance to him: "how our students learn, how we communicate concepts, and how we assess learning." His preservice education gave him a familiarity with reformed perspectives on teaching, but not with the practical experience of teaching. Now as his career has developed, he is pursuing "a more practical style of professional learning," relying on additional qualification courses and workshops on student learning and assessment and working on weaving the "underlying pedagogy and theory" into his work with students and colleagues.

For Liz and her colleagues, the introduction of the Physics First model of teaching helped reveal similar issues of needing to be specific in focusing their professional learning on the needs of a particular reform. In her case, there was a recognition that professional learning needed to simultaneously focus on both content and pedagogy. There was a need to reimagine the way in which physics had been taught, leading to a common departmental understanding of the pedagogy and content of the new program. Developing this common understanding meant, for example, that the labs "that did exist were cookbook in nature, which would need to change with Physics First." Such an approach was invaluable, as a number of teachers "were not necessarily comfortable teaching … outside their content areas." The concentration on working with both the content and the pedagogy required for the Physics First program has given the department confidence in how it can approach the implementation of the *NGSS:* "We brought in experts [and now send] teachers to conferences and professional development workshops."

Mike and Steve's teaching and learning of a reformed vision of science was heavily influenced by the work of their department. Mike was initially skeptical of being involved in the A&E professional development: "OK, here we go again." Two aspects of Mike's vignette are instructive for us. The first is that he made connections between his previous professional learning and the new information he was working with: "One of the biggest impacts was my realization of how A&E can be used to support and strengthen a more accurate representation of science in the classroom." Such an openness to learning allowed Mike to understand *what* aspects of his practice needed to change, *why* they needed to change, and *how* to reform his teaching. All of this is encapsulated in the statement, "If I'm up in the front teaching, then I'm the one who's 'doing science,' and they're sitting there listening but not 'doing science,' … which allows them to opt out of the thinking and learning." The second important aspect of Mike's vignette is that the A&E professional development opportunity was discipline specific. Mike could take the content that was being offered and make use of it in his classroom: "I can meaningfully assess a student's ability to communicate, observe, use critical thinking skills and understandings, self-assess, peer-assess, and give feedback."

Steve was not part of the formal training, but working in a collegial department that made time to talk about practices and working closely with Mike "on the side" allowed Steve to experiment with the reforms in his classroom. Steve noted that communication was key to his learning about the reforms and that the communication needed to reach everybody to build interest in the reform. What is also interesting from Steve's vignette is that the assessment reforms built on the work that the department had already put into teaching the practices of science. Steve instantly saw the value of the assessment reforms: "This was a wonderful thing, especially as it allowed us to assess the practices of science across our subjects. So let's bring it into our classrooms and make the move." In turn, the assessment reforms led to further changes in Steve's classroom practice: "It also means working with students to get them to help each other, especially with descriptive feedback practices." This is an important point, as it highlights how reform is a gradual process and needs to be seen as evolutionary, not revolutionary. As in Liz's department, professional learning opportunities are at their most valuable when they involve teachers with authentic and discipline-specific learning experiences.

Julie learned an important lesson early in her career: "It struck me that not everyone liked the same approaches to learning that I did, and that my job as a teacher was not to change how students best learned but to work with these differences to help all students engage with and integrate new learning experiences." This understanding has shaped a strong commitment to professional learning that respects teachers as learners. In teaching, "there is no 'one' right way to do it; although there are globally effective strategies, sometimes what works for one teacher may not work for another. I think this is reflected in how teachers integrate reforms into their curriculum." This means that a key component in aligning our teaching practices with the ideals of reform documents is encouraging "teachers to more easily see how the reform could work for them and their students." For chairs and other teacher leaders, this means that professional learning in the department must achieve two functions. First, it must affirm both of the fields we are immersed in, education *and* science. Second, it must take into account teachers' prior knowledge, confidence levels, motivations, school structures, and the needs of their specific student populations. The achievement of these functions relies on working with content that helps us implement "the practices and their assessment in our own classrooms [and involves] an appreciation of both real science *and* real teaching. It also involves an openness to teachers adapting reformed ideas that match their comfort levels as well as their students' interests and needs." To successfully develop such professional learning opportunities requires the integration of both theory and practice, a point made by each of our colleagues.

Theory and Practice

Teachers' knowledge is both tacit and explicit, and both forms need to be developed through professional learning opportunities. Teachers are experts at generating tacit knowledge through their classroom work. This tacit knowledge can become explicit knowledge when teachers work with their colleagues and tell stories of practice and "what works." The capacity to tell stories makes "tacit knowledge more visible, call[s] into question assumptions about common practices ... and make[s] possible the consideration of alternatives" (Cochran-Smith and Lytle 1999, p. 294). If we wish to develop teachers' knowledge, then we need to provide the conditions in which there is a "willingness to accept feedback and work toward improvement … respect and trust" (Hord 1997, p. 5). You may have already picked up on the dangers of leaving the responsibility for generating knowledge at a department, school, or even board level. The first is that telling stories of practice only provides information to another teacher; it does not provide knowledge. Second, the desire to tell stories must be fused with a desire to reflect on thoughts, words, and actions. And reflection can only be effective when alternatives become known and explored. In other words, theory and practice need to be two sides of the same coin.

Shawn recognizes just this point when he says that "we can listen and learn from students and colleagues about how students learn, [but] we may never discover if these ideas hold true if we do not desire to experiment with them." For Shawn, the mix of theory and practice is foundational to his learning: "The majority of professional development workshops … have provided a theory on how best to approach different subjects and specific topics within those subjects; these ideas are always supported with practical exercises. … a balance of theory and practice is critical in our growth as effective science educators." Where this balance between theory and practice lies, however, is problematic. For Shawn, in the early stages of his career, the motivating force in finding the balance is the needs of his students; the "balance should be established that works best for the students you have!" That is not a bad rule of thumb.

Liz's experience with the *NGSS* course encapsulates the need to integrate theory and practice: "Through this experience I gained a confidence in working with … [the] *NGSS* that I would not have gained had someone just told me what I needed to know." The strength of the course was that it went beyond making the theory known: "a book study—reading, discussing, and reading some more." Theory and practice were integrated to exemplify "best practices in science education; instead of lecture, we were drawn into discussions and experiences that highlighted the intricacies of the *NGSS*." The net result was "enriching, eye-opening, frustrating, and, most importantly, engaging. I was forced to work with … the *NGSS* in a manner that ultimately gave me a greater understanding of their complexities." And, as with Shawn, the integration of theory and practice was seen as benefiting the teachers and students in Liz's department: "I was also provided with experiences that I could bring back to teachers within the science department and students in the classroom."

The integration of theory and practice for Mike and Steve was much more specific, though no less valuable. Both were already well versed in teaching from a reformed perspective but also realized that their assessment practices had not evolved to align with their teaching. As Mike said, "I thought to myself that I was holding some pretty good work but that today, in many respects, it didn't cut the mustard in terms of my current understanding." For Steve, the benefit was in understanding more about the "processes that students use to manage their learning in the first place." The professional learning on assessment could be linked to his previous work on the practices of science, thus validating and amplifying the importance of his previous work: "It's much more powerful for me and my students when introducing processes such as argumentation." For Mike, the strength of the professional learning was that it involved working with a Ministry trainer, his colleagues, and his students to develop "[his] ability to identify and communicate the success criteria necessary to guide the production of high-quality work and products." The inclusion of students in this is interesting, as the student perspective is often ignored. Further, the focus was on assessing the different forms of evidence of learning that teachers can use rather than using "an accounting tool to crunch only the product or test data and come up with a student's average." By more closely integrating A&E with his reformed teaching practice, Mike has moved closer to more accurately representing science: "It's no longer just about performance on a test, exam, or product."

Julie's vignette brings a different perspective to this discussion. As an experienced chair and facilitator of professional learning opportunities, she highlights the variability in teachers' responses to the integration of theory and practice: "Although most teachers in my own department enjoy learning about the underlying theory and empirical research base of a new educational method, other audiences may find the theory and research less important to their implementation of the work itself." The challenge is to integrate theory and practice in ways that build the credibility of the reform. Teachers need to be "convinced of the likely effectiveness [of the reform] and its suitability for their idiomatic teaching approaches." The alternative is—well, we have all experienced this at some point in our careers—"dogmatic presentations on reform, which, although impassioned and possibly persuasive, can imply a lack of respect for the audience's knowledge and professionalism."

Understanding the relationships between theory and practice is crucial, as is the perceived credibility of the reform in the eyes of the teachers. Credibility can be built when the presentation of the reform is presented in a way that shows, in Julie's words, an "understanding of the real-world classroom" and how students learn in those classrooms. This is the final point that we wish to consider from these vignettes.

How Students Learn

As a beginning teacher, Shawn is clearly (almost idealistically) concerned with how his students learn and how he can learn from them: The "direct experience of students gives an excellent account of your teaching … how it can be modified to best accommodate student learning." This is an admirable position to take, as it appears to be a motivation for reflection on how Shawn can continue to improve this classroom practice "for expanding my foundation in teaching the content and processes of science … in understanding how students learn." Understanding how students learn is also important to Liz, as it gave her confidence in the professional learning that her teachers were undertaking as part of the Physics First and chemistry curriculum changes:

> *We worked through labs as if we were students. We set up equipment, looked at data, compared results, had discussions, and were given the confidence to go into a school year with a new series of courses. … Participating in the program and knowing how our students were learning physics gave our chemistry team a strong foundation from which to build the chemistry curriculum.*

This practical understanding of the professional learning requirements for particular reforms has been reinforced by other forms of professional learning such as collaboration with external experts and sending teachers to conferences.

Despite the apparent success of these professional learning opportunities, Liz implied that they are not the norm. Referring to the *NGSS* course, she says, "I did not expect the course to engage us (teachers) as learners in ways that represented how the standards documents envisioned us engaging with students." However, the content of the course reinforced the efficacy of understanding the content from a student perspective: "We discussed how phenomena could drive a lesson and how student-generated questions … would help students learn not only content but also scientific practices and skills."

Mike highlighted a long-term view of how student learning is changing, a change from discussing what "units will be in a course and the content that will be taught in those units to asking how students learn." This perception is based on the work—of more than 15 years—of his department in promoting a reformed vision of science education. For Mike and his colleagues, students learn by "doing science" rather than by passively listening. Mike's practice is to engage students with science and provide opportunities for them to work with both science content and practices. In addition, he is explicit in working with students to understand what success looks like for the work they are doing so that they know "what it is that they're attempting to do." He also relies on a range of evidence to make sure that learning is appropriately assessed or evaluated.

Not surprisingly, Steve shared a similar long-term view and is concerned with understanding "those processes students go through to understand how science is carried out [and] the processes that students use to manage their learning in the first place." Even as he was working to incorporate the practices of science into his teaching, he also started to look at how assessment needed to change. As a result, he was ahead of the assessment reforms, which have only been implemented in the last few years: "I know that in my classes I never used to do [formative assessment] too much, but I have started to do more over the last six years." Working with students in developing assessment tools has meant changing his perception of himself as a teacher as well. Working with the reforms sees Steve as a co-inquirer into the practices of science, something he takes a quiet pride in: "Questions can be clarified for both the students and myself. I'm a bit of a dinosaur, but I've learned."

Similarly, for Julie, students also learn by doing, where doing is based on a sophisticated understanding of science and with teachers as co-inquirers with their students. The motivation here is the same as what drives Shawn, although they are years apart in terms of experience. For Julie, students learn when they have opportunities for understanding content and making connections and can pursue their own lines of investigation: "This level of engagement in science is what we want for our students, but it is also what we want for ourselves." The creation of lessons and laboratory experiences opens up opportunities that allow teachers to "problem solve as we inquire side by side with our students."

Conclusion

What is interesting in this series of vignettes is that our colleagues identified and have experienced all of the components of the Timperley et al. (2007) framework regarding the content of professional learning opportunities. Occupying different stages in their careers or positions within their departments has made little difference to the main concerns that our colleagues have about the content component of their work. All were driven by a desire to understand how students learn and then use this information to reform their classroom practices to align with the ideals of the reform documents that they were working with. From this intrinsic motivation comes a need to develop both disciplinary and pedagogical knowledge as well as to integrate this knowledge back into their classroom practices.

To support this virtuous cycle of learning, external expertise is important in helping advise and guide the implementation of reforms. The real bedrock on which changes to classroom practice occur, however, is at the department level. In every vignette, the opportunities to discuss teaching and learning—either as a department or with particular colleagues—are seen as crucial to learning and applying new knowledge to the classroom. As such, the content and the context of teacher professional learning become almost indivisible. If we are to build departments that promote teacher professional learning, then we need to embed the content of the reforms into reforming the department. This idea is well understood in the research literature; we need to make it equally understood in departments. It is the professional learning activities that teachers engage in that can become the vehicles for making this connection and then bringing it to life. It is these activities to which we turn our attention in the next chapter.

Summary

- Science teaching can no longer be about the presentation of decontextualized, immutable "facts." The reforms of the past two decades have consistently stressed the need for teachers to develop classrooms in which students work to shape ideas from evidence that explain the *why* and *how* of natural phenomena. As a result, the content of professional learning opportunities must be more than disciplinary knowledge; it must also include how to use that knowledge in a way that reflects the human construct that is science.
- Although we may pursue a broader and deeper understanding of science, we also need to move toward a greater alignment of our teaching practices with the ideals of the reform documents. This means constantly evolving our understanding of teaching and learning.
- Professional learning in the department must achieve two functions. First, it must affirm both of the fields we are immersed in—education *and* science. Second, it must take into account teachers' prior knowledge, confidence levels, motivations, and school structures, as well as the needs of specific student populations.
- Understanding the relationships between theory and practice is crucial, as is the perceived credibility of the reform in the eyes of the teachers. Credibility can be built when reforms are seen as credible and address how students learn in classrooms.

- A focus on how students learn is centrally important when considering the content of professional learning.
- Opportunities to discuss teaching and learning—either as a department or with particular colleagues—are seen as crucial to learning and applying new knowledge to the classroom.

Questions to Consider

1. What are the ways you and your colleagues can support or have supported each other in building robust and flexible content knowledge? How might the dimensions of the *Framework* (i.e., Chapters 3–8) be used within the department to support this pursuit?
2. In what ways can teachers in schools and departments be supported to learn continuously as our knowledge from research about science teaching and learning evolves? What strategies might the department use to ensure that new developments related to science teaching and learning are understood and integrated into the evolving departmental visions of science education? (Consider mechanisms to support teachers' reading and sharing resources from National Science Teachers Association journals or ways to connect with science education leaders outside of the school.)
3. What mechanisms are in place, or could be put in place, to support the integration of what teachers are learning with the expertise and experiences they already have from their years of experience in classrooms?
4. To what extent do departmental or individual discussions center on student work as a mechanism for focusing professional learning on how students learn? When could opportunities for such discussions occur in the school or department?
5. How might the discussions about science teaching and learning in the school or department be enhanced to further support teacher professional learning?

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Page numbers printed in **boldface type** indicate figures.

"Our book gives teachers at different points in their careers a voice in describing their professional learning needs. By combining these voices with theory, we can make use of the department as a place to support all teachers in their reform efforts."

—The authors of *Building the Science Department*

BUILDING THE SCIENCE DEPARTMENT

STORIES OF SUCCESS

If you believe it's important to give teachers a say in how their professional learning needs are met, *Building the Science Department* is the book for you. It asks how your science department can become a site for developing science teachers' professional learning. Then, it provides answers through stories told by teachers who walk the sometimes rocky path of reforming science teaching and learning. The authors also wrote *Reimagining the Science Department*, an NSTA Press guide to changing department-level factors so that reformed teaching and learning are both supported.

***Building the Science Department* is divided into two parts.**

- **The first part deals with scientific activity—its representation in *A Framework for K–12 Science Education* and the *Next Generation Science Standards* and its role in making the science department a place for building professional learning.**
- **The second part uses teacher stories, or vignettes, to work through the components of a professional learning framework—context, content, activities, and processes. After each vignette is a commentary that highlights the key points and implications for teacher learning. Also included are questions to challenge teachers to improve their instructional practices and align them with current reform initiatives.**

By featuring science teachers at different career stages, *Building the Science Department* highlights both the common themes in their professional learning and the ways their learning needs have changed over time. The stories are illuminating for teachers as well as for school administrators, other education leaders, and policy makers.

Grades 6–12

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