

## Chapter 2

# Building Interest and Engagement Through Enrichment Activities

*I love going to the talks. I'm very excited about trying things.  
I like hearing about the new things other people are doing.*

–Biology faculty member

The Teaching and Learning Center (TLC) offers a variety of enrichment programs that bring people together to learn from experts and from one another. This menu of opportunities provides faculty, postdoctoral fellows (postdocs), and graduate students with a venue to learn about effective teaching practices, and fosters dialogue about teaching and learning. Our enrichment programs generally take one of two forms: (1) visits from prominent Visiting Teacher/Scholars who come to share their expertise and engage in conversations, presentations, and brainstorming sessions; and (2) seminars and workshops that are organized by the TLC with university personnel serving as presenters and/or facilitators. In this chapter, we will describe both types of enrichment programs and provide examples of each.

### Visiting Teacher/Scholars

Every semester, the TLC hosts a Visiting Teacher/Scholar who is nationally recognized for his or her ability to integrate effective teaching and science research. Our intent is to showcase individuals who demonstrate that excellence in teaching can coexist with excellence in scientific research.

### *Characteristics of Visiting Teacher/Scholars*

Science research, science education research, and higher education research are distinct disciplinary fields that are often isolated (Henderson, Beach, & Finkelstein, 2011). Our Visiting Teacher/Scholars are the exceptional scholars with formal academic training in the sciences whose areas of expertise and research focus span two or more of these generally discrete specializations.

Our Visiting Teacher/Scholars' research focus can be characterized as fitting into one of three broad categories that represent the overlap between science education

research, science research, and higher education research (see text boxes below for specific examples). These categories are representative rather than exhaustive, and they reflect patterns of ongoing scholarship as well as the types of visitors who are likely to have a positive impact on promoting teaching and learning in the context of our College.

The first category of Visiting Teacher/Scholars consists of individuals who have active research programs in both science and science education. This research combination is rare, and these Teacher/Scholars can serve as role models or inspiration to research faculty in our College. Most of our faculty members have traditional tenure-track career trajectories, and many are skeptical that it is possible to engage in high quality research in both science and science education. The success of these Teacher/Scholars illustrates the possible synergy of science and science education research. Furthermore, we have found that Visiting Teacher/Scholars with dual research foci attract a broader range of seminar attendees, as they can connect with faculty members from both science and education disciplines. The science research of the Visiting Teacher/Scholar serves as a ‘hook’ to draw faculty members, postdocs, and graduate students who are interested in the scientific research area to a session on teaching and learning that they might not otherwise attend.

**Jo Handelsman**, a Howard Hughes Medical Institute Professor, visited us from the Department of Molecular, Cellular and Developmental Biology at Yale University. Handelsman, a microbiologist with more than 100 scientific research publications, is also widely renowned for her work on scientific teaching, professional development for current and future biology faculty members, and science education policy for higher education (Handelsman et al., 2004; Handelsman, Miller, & Pfund, 2007). Her science research drew many of our faculty members to attend her seminar and small meetings. In these interactions, Handelsman shared her vision on postsecondary STEM education and exposed our faculty to national policy conversations related to undergraduate STEM education and reform.

*I strongly believe my teaching style has benefited from my interactions with [Dr. Handelsman]. She has given me numerous tips and strategies for the classroom!*

—Graduate student in Chemistry

The second category of Teacher/Scholar consists of faculty members who began their academic careers as research scientists but now focus primarily on science education research (Bush et al., 2008). These individuals are usually national leaders in developing and implementing innovative practices in teaching and learning. They generally have published extensively on their teaching and learning initiatives, won awards for these initiatives, and developed model programs that can be widely replicated.

**Diane Ebert-May**, a biology education researcher who visited us from the Department of Plant Biology at Michigan State University, has published extensively on teaching and learning in undergraduate biology courses. Her science education research interests include the incorporation of evidence-based active learning approaches in large enrollment undergraduate biology courses and professional development for future faculty (Ebert-May et al., 2011; Ebert-May & Hodder, 2008; Wyse, Long, & Ebert-May, 2014). Many of our faculty members are in the process of redesigning their own large enrollment courses, and were interested in learning from Ebert-May about overcoming the many barriers to implementing innovative, learner-centered approaches in this type of course.

*It was just fascinating to listen to [Diane Ebert-May's] talk . . . hearing her talk about stuff she's done. [These talks] always get me excited about trying to do something new or different.*

—Biology instructor

The third category includes higher education administrators who have initiated major STEM reforms and conducted research on or evaluated those initiatives. These administrators generally have a background in scientific research, but have subsequently assumed major campus and/or national leadership roles. They provide a perspective on change initiatives that go beyond departmental and sometimes even college boundaries. Their science background makes their perspective more relevant to our faculty members, postdocs, and graduate students than would be the case with administrators with non-science backgrounds.

At the time of her visit, **Claudia Neuhauser** was the Vice Chancellor for Academic Affairs at the new campus of the University of Minnesota, Rochester. In this role, she developed and evaluated innovative interdisciplinary degree programs and courses, and promoted ongoing education collaborations across disciplines. Neuhauser is a mathematician by training, and her research interests have spanned areas of biology across levels of organization, from the genome to ecological communities. During her visit, Neuhauser met with individuals and groups who are engaged in ongoing initiatives to enhance interdisciplinary connections between biology, chemistry, physics, and mathematics.

*The meeting with Claudia was interesting. [We discussed] our intention about scaling up and how we imagined doing that . . . [and] our design strategies.*

(continued)

*She was very positive about what we're doing ... and having her reflection on our decisions about interdisciplinary education will be useful in moving forward.*

—Postdoctoral research fellow who works on interdisciplinary initiatives in the University of Maryland (UMD) Physics Education Research Group

In selecting Visiting Teacher/Scholars, we strive for diversity in scientific disciplines to represent the four departments that we serve. We also seek Teacher/Scholars who are engaged in change initiatives that corresponded closely to our own. In this way, the Teacher/Scholars are particularly relevant for our audience, and their visits can help establish extended collaborations.

*I have attended nearly every talk in your Visiting Teacher/Scholar series and met with many of the visiting scholars. As I had recently moved from a pure research institute to an academic environment where teaching is central, this series was instrumental to my teaching. From models of teaching and engaging students to creating opportunities for active learning in the classroom, the topics of the series have been incredibly relevant to every aspect of my teaching activities.*

—Biology faculty member

### Activities with Visiting Teacher/Scholars

Visiting Teacher/Scholars typically spend two days on campus. During that time, they offer a seminar on teaching and learning and meet with faculty, postdocs, and graduate students individually and in small groups. Some Visiting Teacher/Scholars also give a second seminar that focuses on their current scientific research. As much as possible, meals with the Visiting Teacher/Scholars are planned as community events, and generally include dinner with faculty members and lunch with graduate students. Having many meetings of different types provides the opportunity for large numbers of faculty members, postdocs, and graduate students to interact with the visitors.

*It always feels relieving to hear from a visiting scholar that they started off just like us, graduate students with a vocation and determination. That gives us hope that someday we can make it to stardom, like they have.*

—Graduate student in Chemistry

The visit typically begins with a breakfast meeting with the TLC staff, who provide an introduction to the history of the TLC, the objectives of the Visiting Teacher/Scholar program, and background on science education initiatives currently underway in the College. We have found this to be a helpful orientation for visitors because of the uniqueness of our disciplinary center. This introduction allows them to understand our institutional context and tailor their remarks accordingly. The meeting also provides opportunity for the TLC staff to seek advice from the Visiting Teacher/Scholar on professional development, curriculum development, and institutional transformation quandaries.

For additional information on logistics and preparations for hosting a Teacher/Scholar, see the Tip Sheet in the Implementation Guide. For a historical list of all TLC Visiting Teacher/Scholars, see [cmns-tlc.umd.edu/VTS](http://cmns-tlc.umd.edu/VTS).

## Seminars and Workshops

The second type of enrichment activity consists of seminars and workshops hosted by the TLC with university personnel serving as presenters and/or facilitators. These seminars and workshops provide a low-distraction environment to introduce participants to innovative practices and develop their expertise in science teaching. The duration of a given program varies depending on content and objectives, with seminars typically lasting about an hour and a half and workshops generally lasting between one and four hours.

Given the many responsibilities that our audience must balance, the short format of the seminars and workshops makes them accessible and enables us to introduce these topics to relatively large groups. Additionally, our enrichment activities sometimes serve as gateway activities in that they introduce faculty members to the TLC's activities and to topics in teaching and learning. Conversations and interests that are initiated in seminars and workshops often continue in different settings. These interests may be pursued through more in-depth professional development, in long-term course redesign collaborations between faculty members who teach interconnected courses, and in other reform initiatives.

In this book, we refer to **seminars** as professional development activities in which one or more experts brings new knowledge to a group with a shared interest in a topic, with most of the meeting time dedicated to the experts' presentation of this topic. While the experts' sharing of knowledge is the primary focus of the seminar, it may also include an opportunity for audience discussion or question and answer sessions following the presentation.

**Workshops** differ from seminars in that the presentation component is shorter and serves to provide a basic introduction to a topic. Workshop participants actively engage in one or more activities related to the topic during the majority of the meeting time.

## ***Guiding Principals in Developing Seminars and Workshops***

Our seminars and workshops are intended to follow best practices in adult learning. Many aspects of our workshops reflect Knowles' (1980) principles of adult learning:

- *Adult learners are internally motivated and self-directed.* Participants play an active role in our seminars and workshops, and the format is designed to facilitate their learning.
- *Adult learners have accumulated a wealth of knowledge through their experiences.* Our workshops build upon participants' existing knowledge of teaching and learning, and frequently draw upon participants' teaching experiences.
- *Adult learners are goal-oriented and practical.* Our programs have clearly defined goals related to our participants' tasks and challenges as instructors.
- *Adult learners are relevancy-oriented.* Through our disciplinary focus, we ensure that our programming is highly relevant to the work of our audience.
- *Adult learners should be respected.* We provide detailed information on the objectives and content of the upcoming seminars and workshops (e.g., detailed abstracts, readings, background information on guest speakers, and links to online resources) so that potential attendees know exactly what they can gain from attending.

### **The Value of Offering Food**

We have found it very important to provide food at our workshops and seminars. Providing food serves multiple purposes: the food is an incentive to attend; it creates a collegial, community atmosphere; and it demonstrates institutional support.



## ***Selecting Seminar and Workshop Topics***

One of the most important aspects of planning seminars and workshops is determining the topics to be covered, and ensuring that these topics will appeal to our audience and be relevant to their work and professional development needs. In planning specific topics for our workshops and seminars, we consult with our stakeholders (i.e., dean, department chairs, faculty members, graduate students) to learn what topics interest them. TLC staff also recommend topics that seem relevant and interesting to our stakeholders, such as current College curricular revisions.

## ***Evaluation of Seminars and Workshops***

Following some seminars and workshops, we request that participants complete an evaluation survey. Such surveys generally include items with a rating scale as well as open-ended questions. Through these evaluations, participants have provided helpful feedback that has enabled the TLC to better tailor seminar and workshop topics, formats, and materials to the needs and preferences of our audience.

## ***PCK Focus of Seminars and Workshops***

All TLC enrichment programs are focused on teaching and learning specifically as it applies to biology and chemistry. Due to this disciplinary focus, our programs provide pedagogical content knowledge (PCK) rather than general pedagogical knowledge. We offer a broad range of topics within this targeted content area, and our workshops span the five components of PCK: (1) student understanding of science, (2) science curriculum, (3) instructional strategies, (4) assessment of student learning, and (5) orientation to teaching science. See Chap. 1 for more details about PCK and its components.

*I'm glad that we have a disciplinary teaching and learning center. I did go to a lot of workshops offered by the campus Center for Teaching Excellence, but it was so skewed to humanities and not sciences, and labs are [a] totally different beast from discussion sections.*

–Biology instructor

In the subsequent sections, we describe each PCK component, and provide an example of a seminar or workshop that addresses the component. The Implementation Guide provides detailed descriptions of these sample workshop and seminars, and includes seminar/workshop timelines, activities, materials, and suggestions for supplemental readings.

## PCK 1: Student Understanding of Science

The first PCK component refers to knowledge about how to assess and address students' prior knowledge, construction of knowledge, and diversity. The theory of constructivism suggests that learning occurs as students iteratively connect new knowledge to prior knowledge, which is built through previous academic work as well as experiences in everyday life (Ausubel, 1968; Bruner, 1960; Mintzes, Wandersee, & Novak, 2005; Piaget, 1954; Vygotsky, 1978). This prior knowledge may be valid in that it aligns with widely accepted scientific theories, or it may be inconsistent with accepted theories, in what is commonly termed an alternative conception (Fisher, 1983; Gilbert, Osborne, & Fensham, 1982; Thijs & van den Berg, 1993). Empirical studies indicate that prior knowledge strongly impacts academic success (Bloom, 1976; Dochy, Segers, & Buehl, 1999; Marzano, 2004; Tobias, 1994). Therefore, it is important for educators to be aware of and adjust their teaching based on students' prior knowledge.

**Alternative conceptions** or 'misconceptions,' are commonly held ideas that are inconsistent with a concept as it is understood by scientists (Thijs & van den Berg, 1993). Alternative conceptions have a variety of generative causes (Fisher, 1983; Gilbert et al., 1982; Marbach-Ad, 2009; Thijs & van den Berg, 1993), such as arising from everyday life experiences or students' overgeneralization. It is important to understand the generative causes of alternative conceptions, because this helps to target learning strategies to overcome them (Krause, Kelly, Tasooji, Corkins, & Purzer, 2010).

In any given class, students vary in terms of their prior knowledge and framework for integrating new knowledge. This diversity may stem from different cultural backgrounds, academic trajectories, retention of prior learning, and learning styles (Birenbaum & Dochy, 1996; Magnusson, Krajcik, & Borko, 1999). However, faculty members do not always address this diversity. In some cases, faculty members teach as if all students enter their course with no relevant prior knowledge. In other cases, faculty members work under the assumption that all students bring sufficient knowledge from prior coursework. Neither assumption is likely to be true, so it is valuable for faculty members to verify their assumptions about student prior knowledge.

In the departments that we serve, we find it particularly important to probe students' prior knowledge in first- and second-year introductory courses. For second-year courses this is especially important because students come via multiple paths; some have earned Advanced Placement credit in high school that allows them to move directly into second-year courses, others may have transferred from two- or four-year institutions, and still others have taken prior coursework in our own institution. Each of these paths has implications for what students were previously



taught. Instructors should also probe prior knowledge in upper level courses, due to differences in students' prior coursework and content retention.

In our professional development programming related to this PCK component, we have two overarching goals. First, we seek to raise awareness of the importance of understanding and addressing students' prior knowledge. Second, we aim to expose participants to varied tools that they can use to gauge their students' prior knowledge and to support them in using these tools.

In seminars and workshops related to this PCK component, presenters or facilitators share strategies for gauging students' prior knowledge, such as pretests, surveys, interviews, and classroom activities. For example, one faculty member presented an innovative mechanism for gauging students' prior knowledge through concept mapping (described more fully in the Implementation Guide). This workshop provided an overview of common alternative conceptions in the chemical and life sciences, and offered strategies for overcoming those alternative conceptions. We began with an introduction and definition of key terms related to alternative conceptions. Participants then engaged in small group activities to identify students' alternative conceptions, investigate their causes, and explore instructional techniques to overcome them. The workshop concluded with several brief research presentations on identifying and addressing prevalent alternative conceptions held by high school chemistry and undergraduate biology students.

## **PCK 2. Science Curriculum**

The second PCK component refers to knowledge of curriculum within and across courses. Curriculum is a term with a nebulous meaning and many definitions (Brandwein, 1977; Egan, 2003; Wiggins & McTighe, 1998). Wiggins and McTighe (1998) define curriculum as “the specific blueprint for learning that is derived from *desired results*—that is, content and performance standards” that may be locally or externally determined (pp. 5–6; emphasis in original). Literature on curriculum emphasizes that it is not just a list of topics to be covered, but an organizing framework for content delivery and a map for how and when to teach desired content (Graff, 2011; Kauffman, Moore, Kardos, Liu, & Peske, 2002; Wiggins & McTighe, 1998). Here, we refer to curriculum as the topics that are taught in a single course or across courses. Our conceptualization of curriculum encompasses how topics are taught only in a very general way, and does not include the level of specificity of lesson plans, instructional strategies, and instructional materials, which we include in PCK 3.

Developing curriculum should be a deliberate and systematic process. Wiggins and McTighe (1998) recommend using a backward design approach to building curriculum. This design involves first identifying desired results or learning goals, then determining acceptable evidence for whether students have achieved the desired results, and only then sequencing topics and planning instructional activities (Wiggins & McTighe, 1998). This backward design approach, when applied to

individual courses and sequences of courses, promotes coherence in what students learn and how they assimilate into a discipline.

Curricular knowledge is generally understood to have two dimensions: vertical and horizontal (Shulman, 1986). Vertical curriculum refers to what is taught in a subject area across courses and years of study. Horizontal (or lateral) curriculum refers to what is taught simultaneously, whether in parallel courses (e.g., multiple sections of introductory biology) or in related courses that students take in any given semester (e.g., introductory biology and chemistry courses). Course instructors should be aware of what is commonly taught in related courses, whether vertically or horizontally aligned with their own course.



As a professional development providers in a large university, we work with faculty members who teach related courses as well as faculty members who teach multiple sections of a single course to align learning goals and materials across the spectrum of undergraduate study. In both cases, much of our professional development focuses on student learning progressions, and how curriculum alignment can promote coherence and the development of knowledge. To respect faculty members' academic independence, we collaborate with them to build an understanding of best practices in curriculum development and support them as they apply these practices in their own courses. In accordance with national recommendations (AAAS, 2011), our approach emphasizes depth over breadth of content coverage. We also promote the use of empirically validated, content-specific learning progressions to guide curriculum development.

**Learning progressions** are “research-based cognitive models of how learning of scientific concepts and practices unfolds over time” (Duncan & Rivet, 2013, p. 396). They map pathways that students may follow in developing more sophisticated understanding of key ideas and skills necessary for science literacy (Fortus & Krajcik, 2012). Using learning progressions to guide curriculum design supports coherence within and across courses (Duschl, Schweingruber, & Shouse, 2007).

In seminars and workshops related to this component of PCK, we address topics such as student learning progressions, content and course sequencing, and strategies for emphasizing conceptual understanding rather than content coverage. These seminars and workshops sometimes address curricular changes within a single course, and may include brief presentations from faculty members on how and why they changed the topics and/or sequencing of topics within their course. Other seminars and workshops address coordinated changes across multiple interlinked courses. In all of these programs, we emphasize how faculty members can collaborate to better understand the knowledge that students bring from one course to another, so that faculty members can more effectively bridge student understanding across courses.

The Implementation Guide describes one of our workshops on initiating, coordinating, and implementing curricular innovations. In this workshop, we provided two examples of recent large-scale curricular changes from our College: reordering introductory general and organic chemistry classes to move organic chemistry earlier in the sequence and building a curricular continuum between nine undergraduate microbiology courses. As part of the workshop, we encouraged more changes of this type and provided examples of how the TLC can support these changes.

### **PCK 3. Instructional Strategies**

The third component of PCK refers to an awareness of instructional strategies and an understanding of how to employ those strategies appropriately and effectively. In recent years, emerging research and national policy recommendations have strongly supported the use of student-centered instructional approaches (AAAS, 2011; Freeman et al., 2007, 2014; Marbach-Ad & Sokolove, 2000; NRC, 2003; Smith, Wood, Krauter, & Knight, 2011). These approaches reflect a perspective on the purpose of higher education as not focused on transmitting knowledge, but rather on creating an environment in which learners are engaged in their learning and construct their own knowledge (Handelsman et al., 2007; Wieman, 2007).

Research focused on teaching in the sciences highlights the importance of teaching science with the same rigor that is applied to scientific research. This

idea, termed scientific teaching, suggests that science educators should employ evidence-based teaching approaches and reiteratively assess the effectiveness of those approaches (Handelsman et al., 2004, 2007). Instructors at the university level are well equipped to employ the scientific teaching approach because of their extensive training as researchers.

Seminars and workshops centered on this component of PCK focus on expanding the use of evidence-based, student-centered instructional strategies, including inquiry-based learning, cooperative and collaborative learning, and technology-aided instruction. In some cases, these workshops and seminars consist of presentations by science instructors in which they provide specific examples from their own classroom. In other cases, the seminars and workshops are led by science education specialists and focus on research about the effectiveness of and appropriate uses for different evidence-based strategies.

One of the TLC's recent seminars in this theme dealt with blended learning and different ways in which blended learning techniques can be used productively in science classes. Administrators as well as faculty members have expressed interest in increasing blended learning offerings in our undergraduate program. This seminar complemented professional development offered by the campus Center for Teaching Excellence and Office of Learning Technologies. In our seminar, four faculty members served as panelists and shared their experiences using different configurations of blended learning in different types of courses. After this panel presentation, the entire group engaged in a conversation about the possibilities for and implications of incorporating blended learning in science coursework. We describe this seminar in more detail in the Implementation Guide.



**Blended learning** combines face-to-face instruction with computer-mediated or online learning. The online approach may be synchronous (live) or asynchronous (self-paced), and often includes a combination of the two. Blended learning can use a variety of media and incorporate different degrees of interactivity. It may principally include expository instruction via recorded lectures and static materials, or it may foster a more constructivist approach through activities such as scenario-based learning experiences and simulated modeling. In the online component of blended learning, students often interact with each other and with the instructor, which offers an opportunity to increase the number and frequency of those interactions without increasing face-to-face instruction. The online component may include quizzes or other assessments, differential supports based on student performance, and some degree of learner control over which instructional activities and how much instruction are accessed.

#### **PCK 4. Assessment of Student Learning**

The fourth component of PCK addresses methods and instruments for assessing student learning. As the backward design approach suggests, assessments should be aligned with learning goals and instructional activities (Handelsman et al., 2007; Wiggins & McTighe, 1998). Classroom assessment helps instructors to better understand how well their students are learning course materials, and allows them to adjust their teaching to help students progress in the material and become better learners (Angelo & Cross, 1993). Assessment also helps students to understand their progress in learning and to adjust their learning efforts and strategies appropriately (Handelsman et al., 2007). Different methods and instruments can play a complementary role in aligning to different learning goals and providing different types of feedback.

The large body of literature on assessment uses multiple typologies. Some literature separates assessment into categories based on its purpose. Angelo & Cross (1993), for example, describe three broad purposes: assessing course-related knowledge and skills; assessing learner attitudes, values, and self-awareness; and assessing learner reactions to assessment. Another common categorization of assessment highlights the differences between formative and summative assessments (Black & Wiliam, 1998; Middle States Commission on Higher Education, 2007; Sadler, 1989). Formative assessments measure students' learning progress throughout a course or course of study and are usually used internally. The goal of formative assessments is to provide feedback to instructors and to students to improve the performance of individual students rather than to judge their performance. Summative assessments generally occur at the end of a teachable unit, course, or

program, and may be used for internal, external, or accountability purposes. The primary goal of summative assessment is to judge student performance and to determine whether students achieved overall goals associated with the unit, course, or program. Formative and summative assessments play complementary roles in improving student learning and the effectiveness of instruction.

Different assessment instruments and item types can be used depending on the purpose of the assessment, since different types may be more appropriate for some learning goals than for others (Magnusson et al., 1999). Professional development in this area can introduce instructors to the wide variety of available instruments and items. Assessment tools should go through a validation process to ensure their validity and reliability. While some assessments may be ungraded, most assessments are graded. Grading techniques vary based on the assessment and item type. Multiple-choice items tend to be relatively straightforward and efficient to grade, but are not appropriate in every context. Open-ended items such as constructed response items, portfolios, and presentations are more difficult to grade. Grading rubrics promote objectivity in grading open-ended items and can increase inter-grader reliability.

Databases such as the Field-tested Learning Assessment Guide (FLAG) serve as valuable resources for instructors to use to explore different assessment types and access validated assessment tools and grading rubrics ([www.flaguide.org](http://www.flaguide.org)). Instructors within a department may also collaborate with their peers to validate tools that they develop and/or share assessments or items across sections or even courses.

Assessment is intertwined with other PCK components and therefore is addressed indirectly in a number of our seminars and workshops. In this section, we refer only to seminars and workshops with a primary focus on assessing student learning. In these seminars and workshops, we share assessment tools; explore assessments that measure different levels of student understanding; and discuss different mechanisms for grading, such as using rubrics to evaluate open-ended questions. These seminars and workshops provide a venue for introducing faculty to a wider range of assessment practices than the traditional exams that most faculty members rely on, and give them concrete ideas for how differing assessments can be implemented effectively and efficiently.

In the Implementation Guide, we describe a workshop led by a nationally recognized expert in assessing undergraduate students' understanding of science. This workshop provided a broad overview of the types and purposes of assessment, as well as a hands-on activity to explore different types of assessment tools that may be used to uncover how students understand complex course content. Assessment knowledge is considered to be the highest stage in teacher professional growth (Avargil, Herscovitz, & Dori, 2012). Given the complexity of knowledge of assessment, we brought in an outside expert to lead this workshop and introduce our faculty to current research and theory in this area.

## **PCK 5. Orientation to Teaching Science**

This PCK component addresses knowledge and beliefs about the way science should be taught and the goals of teaching science. The theory of scientific teaching (Handelsman et al., 2004, 2007) has increasingly shaped orientations to teaching science around its call to approach the teaching of science with the rigor and reliance on evidence that characterize scientific research. The graduate training that future faculty members receive builds their identity as scientific researchers who approach their scientific research with emphasis on rigor and empirical evidence. This graduate training generally does not equally focus on building future faculty members' identities as science teachers. This identity as a science teacher shapes much of the instruction that occurs in classroom (Kember & Kwan, 2000; Magnusson et al., 1999), but may be underdeveloped in new instructors.

Our professional development in this area is designed to support faculty members as they shape their identities as reflective, reform-minded teachers. Rather than suggesting what this identity should be, we provide opportunities for faculty members to explore what they think a reflective, reform-minded teacher looks like and to foster this identity in themselves. Developing this identity prepares teachers to face the unique challenges that their profession entails, particularly in light of the national call to improve undergraduate science education.

In seminars and workshops that address this area of PCK, we cover topics including how to identify what constitutes effective teaching, the expected outcomes of effective teaching, and how to approach teaching in a way that promotes optimal outcomes. Examples of such seminars and workshop topics include developing a teaching philosophy, discussing prominent reform recommendations for improving science education, and identifying desired outcomes for teaching and learning. Many of these seminars and workshops provide an opportunity for participants to engage in reflection about their own teaching as well as to consider how best practices and national reform efforts can and should be incorporated in their teaching.

In the Implementation Guide, we share an example of a workshop in which biology faculty members collaborated in the identification of the hallmarks of effective teaching, which informed the creation of a rubric for peer review of teaching. This three-and-a-half hour workshop was held during a faculty retreat for the biology department. The purpose of the workshop was to engage the entire department in a discussion of what constitutes effective teaching and how effective teaching is manifested in the classroom. The workshop was part of an extended process to create a systematic approach to peer review within the department, led by the department chair with assistance from a small committee of faculty.

## Conclusion

The activities described in this chapter served as gateway activities through which many faculty members, postdocs, and graduate students were introduced to the services of the TLC and to topics related to teaching and learning. Given this gateway role, it was particularly important that the focus of Visiting Teacher/Scholars, seminars, and workshops reflected the target audience's needs and interests. The examples we mention above and describe in the Implementation Guide were specifically designed for our audience and can be adapted as appropriate for other contexts.

## Implementation Guide

The Implementation Guide includes tips for Teacher/Scholar visits, as well as outlines of sample seminars and workshops. These materials may be used and adapted as needed.

### *Tips for Hosting a Successful Teacher/Scholar Visit*

#### **Selecting and Recruiting Visiting Teacher/Scholars**

- Seek suggestions from college and departmental leadership, as well as faculty members who are active in change initiatives.
- Seek suggestions from teaching and learning specialists in the university, e.g., director of campus teaching and learning center.
- Draw upon your professional networks to get recommendations for emerging Teacher/Scholars.
- Take advantage of related events in your area and invite Teacher/Scholars who may be visiting your area for other reasons. This may provide an opportunity to save on travel expenses and to bring Teacher/Scholars who may not otherwise have availability to plan an independent visit.
- Plan early and be flexible. In our experience, many prominent Teacher/Scholars need ample advance notice—at least a semester and sometimes as much as a year—to schedule their visit. If the suggested semester does not work for the visit, a future semester may.
- Give as much detail about the visit as possible in the invitation letter. The letter should specify length of visit, possible timeframes, audience, research areas of interest, and funding support if available.



## Publicizing the Visit

- After scheduling a visit, request a seminar title, abstract, and short biosketch from the Teacher/Scholar. This information is needed to begin publicizing the visit.
- Publicize the visit through multiple avenues and to multiple audiences. We generally create a webpage on the TLC website (e.g., [cmns-tlc.umd.edu/handelsman](http://cmns-tlc.umd.edu/handelsman)); send announcements to departmental electronic mailing lists for faculty members, postdocs, and graduate students; and post notices on the campus-wide event calendar.
- Invite faculty members, postdocs, and graduate students to schedule individual or small group meetings with the visitor.
- Send targeted emails to college and university administrators who may be particularly interested in the topic of the seminar and/or meeting with the visitor.
- Seek out specific faculty members or groups of faculty to meet with the visitors, based on your knowledge of their research interests and teaching initiatives.
- Send save-the-date notices a month before the visit and a reminder notice a few days before the visit.

## Creating an Agenda of Activities

- Begin the visit with a meeting with teaching and learning center staff, who provide an introduction to the center, a summary of the objectives of the Visiting Teacher/Scholar program, and an overview of relevant science education initiatives currently underway in the college.
- Make the seminar the centerpiece of the visit. Schedule the seminar at a time when most faculty members are not teaching class. We have found 3:00 to 4:30 pm to be the best time, but this may vary based on the institution's class schedule. Book the seminar room as soon as a date for the visit has been selected.
- Reserve at least one meal for graduate students and postdocs to eat with the visitor. Some visitors prepare special remarks for this audience, while others prefer a more casual, open-ended discussion.
- Send the agenda to the visitor at least a few days prior to the visit. Include details about meeting participants and, if a meeting is based around a specific reform or change (e.g., redesign of the introductory chemistry sequence), include relevant information or website links.

## *Example Seminars and Workshops by PCK Component*

On the pages that follow, we share details about the workshops and seminars that were mentioned earlier in the chapter. For each seminar or workshop, we provide an overview of the session structure, content, materials, and interactive activities. These details are intended to illustrate how seminars and workshops can build participants'

knowledge of each PCK component and to assist faculty development providers in the implementation of these or similar workshops in their own institutions.

### **PCK 1: Overcoming Students' Alternative Conceptions in the Chemical and Life Sciences**

The TLC Director facilitated this 90-min workshop and invited select course instructors to share their experience and research addressing students' alternative conceptions. In addition to these presentations, participants engaged in small group activities. Workshop components are outlined below and described in the pages that follow.

1. **Introduction and Definitions of Key Terms (5 min)**
2. **Generative Causes of Alternative Conceptions (25 min)**
3. **Identifying and Overcoming Alternative Conceptions (20 min)**
4. **Course Instructor Experience and Research (30 min)**
5. **Question and Answer (10 min)**

#### **1. Introduction and Definitions of Key Terms**

At the start of the workshop, the facilitator provided definitions of concept, conceptions, and alternative conceptions. The facilitator also discussed key characteristics of alternative conceptions:

- Alternative conceptions are widely shared and may exist across many countries, within a variety of cultural and environmental contexts, although some alternative conceptions may be culturally dependent.
- Alternative conceptions can be similar to views that were held by scientists in the past.
- Alternative conceptions are very persistent (Krause et al., [2010](#)).

**Concept** is the scientific idea underlying a class of things or events, as currently accepted by the scientific community and documented in leading textbooks. A concept acquires its meaning through its network of relationships with other concepts.

**Conception** refers to an individual's idea of the meaning of a concept. Such an interpretation would usually have some idiosyncratic features, even if the individual is a scientist.

**Alternative Conception**, or 'misconception,' refers to a conception that in some aspects is contradictory to, or inconsistent with, the concept as intended by the scientific community. Such inconsistency usually shows in one or more relations of the conception with other conceptions. It thus often involves more

(continued)

than one concept. We only talk of alternative conceptions if alternative ideas have some robustness and persistence across ages and levels of schooling.

–Thijs & van den Berg, 1993

## 2. Generative Causes of Alternative Conceptions

Participants worked in small groups or individually to complete a worksheet with questions that typically elicit students' alternative conceptions. The questions can be seen in the box; the alternative conceptions that these questions should uncover, as well as explanations of their possible generative causes, can be found in the Annotated Alternative Conceptions Worksheet in Chapter 5.

### Alternative Conceptions Worksheet

1. Why do seasons happen? Why is it “hot” in the summer and “cold” in the winter? (Schneps & Sadler, 2003)
2. Why do we have different phases of the moon? (Schneps & Sadler, 2003)
3. Why, in hospitals, might nurses take the plants from patient rooms at night?
4. The balloon was left out in the sun. Why did the balloon pop?
5. Consider a copper wire. Divide it into two equal parts. Divide one half into two equal parts. Continue dividing in the same way. Will this process come to an end? (Stavy & Tirosh, 2000)
6. Two roommates fall ill: one has an ear infection and one has pneumonia. Is it possible that the same causative agent is responsible for both types of disease?
  - (a) Yes, because both individuals live in the same room and therefore the source of the infection has to be the same.
  - (b) Yes, because the same bacteria can adapt to different surroundings.
  - (c) No, because each bacterium would cause one specific disease.
  - (d) No, because one infection is in the lung while the other is in the ear.
  - (e) I do not know the answer to this question. (Marbach-Ad et al., 2010)
7. Two sugar cubes are added to a bowl containing 20 oz of water. One sugar cube is added to a bowl containing 10 oz of water. Which bowl of water is sweeter?
8. Cats usually have five digits on each paw. Omer has a cat with six digits. Omer's cat gave birth to two kittens that also had six digits. How can you explain this? Was something transmitted from the mother to the kittens? If so, what is it? (Marbach-Ad & Stavy, 2000)

**Table 2.1** Generative causes of alternative conceptions and related questions from alternative conceptions worksheet

Generative causes of alternative conceptions	Question(s)
Everyday language/experience	1, 2, 3
Intuition	4, 7
Over-generalization	2, 5, 6
Under-generalization or over-simplification	3
Confusion between extensive and intensive entities	7
Connections between the macro- and micro-level	8

After finishing the worksheet, the entire group reconvened to identify the alternative conceptions that the worksheet may elicit and categorize them based on their possible causes or origins. To guide this discussion, the facilitator provided a list of generative causes of alternative conceptions (Table 2.1).

Following this discussion, the facilitator showed the opening scene from the video “A Private Universe” (Schneps & Sadler, 2003). This scene summarizes characteristics and possible generative causes for students’ alternative conceptions in astronomy, as documented through interviews with Harvard graduates, their professors, and a bright ninth-grader who has some confused ideas about the orbits of the planets.

Participants were then divided into homogeneous groups based on their discipline (Biology, Chemistry, Physics, and Mathematics). Each group received one generative cause for alternative conceptions. The groups were tasked with finding examples of alternative conceptions that can emerge from this generative cause, based on their experiences in the classroom. Finally, each group summarized their examples on posters, which were hung up on the walls of the room for other participants to view.

### 3. Identifying and Overcoming Alternative Conceptions

The facilitator discussed potential ways to identify alternative conceptions through different types of assessment:

- Responding to open-ended questions
- Paraphrasing key terms
- Drawing visual representations of concepts and relationships between concepts (e.g., concept mapping)
- Creating word association

After providing this global overview of assessment tools, the facilitator then focused on concept maps. She discussed how concept maps can be used not just to identify alternative conceptions but also to overcome them.

Participants split into groups of about five people to build their own concept map. Each group was given the same set of concepts: living things, plants, animals, molecules, water, motion, states, liquid, solid, gas, and heat (concepts taken from Novak and Gowin (1984), p. 18), with each concept written on a card. The groups then arranged the cards on a large piece of paper in a logical order that allowed

them to make as many connections as possible between concepts. They then drew lines between concepts and came up with propositions to describe the relationships between the concepts. Once they were finished, each group hung its concept map on the wall to share with the others.

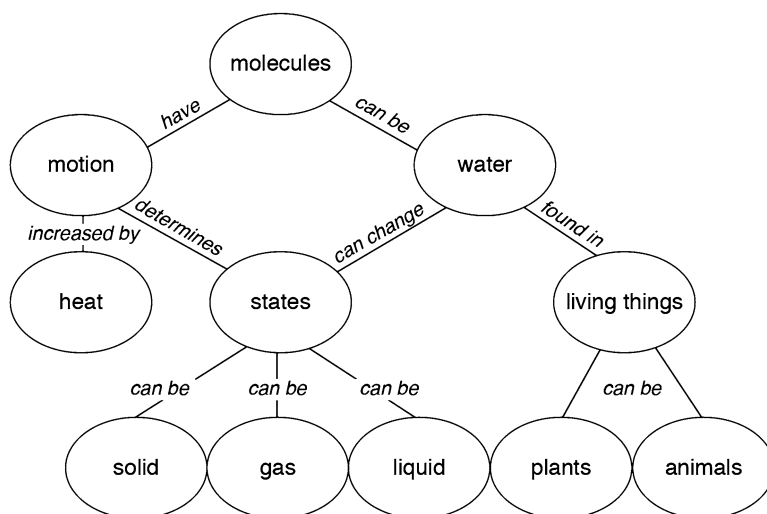
The whole group then discussed the many possible maps that could be drawn to connect these 11 concepts, and highlighted differences in the concepts maps that the groups had created. The facilitator also shared the two examples below (Novak & Gowin, 1984) to show the different ways that students can conceptualize the same set of concepts. For example, concepts can be arranged from the micro level (molecules) to the macro level (multicellular organisms), as in Fig. 2.1, or from macro level to micro level, as in Fig. 2.2.

#### 4. Faculty experience and research

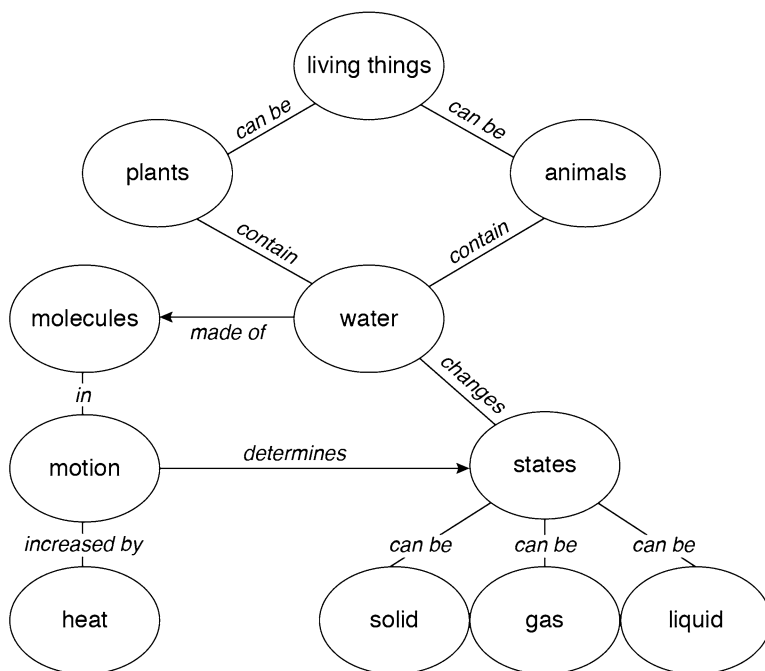
A panel of three faculty members and a graduate student shared examples of how they have identified alternative conceptions and used concept maps in their classes.

The first presenter was a chemistry educator who shared his research involving high school chemistry students. He found that students had difficulties connecting macro-level phenomena with micro-level explanations, and sometimes incorrectly applied macroscopic ideas to the molecular world. The presenter pointed out that alternative conceptions resulting from these difficulties persist throughout high school and even to the undergraduate level (Stieff, 2005).

The next panelists, the instructor and GTA of an upper-level undergraduate immunology course, presented their research on the use of concept mapping as a voluntary homework exercise in their class. The research team, which consisted



**Fig. 2.1** Hierarchical concept map arranged from micro level to macro level. (Novak & Gowin, 1984)



**Fig. 2.2** Hierarchical concept map arranged from macro level to micro level. (Novak & Gowin, 1984)

of the panelists as well as a science education specialist, analyzed all concept maps and identified common alternative conceptions. Analysis of midterm and end-of-semester online student surveys revealed that students found concept mapping helpful as a method of organizing course material (Cathcart, Stieff, Marbach-Ad, Smith, & Frauwirth, 2010).

The final panelist presented his findings from research comparing several approaches to overcome students' alternative conceptions: clickers, concept mapping, and building Wikis. Students reported that both the concept mapping and the Wikis were useful for seeing the “big picture” and helpful in making connections between course concepts. Overall, students preferred creating Wikis to creating concept maps.

## 5. Question and Answer

The workshop ended with a 10-min question and answer period. Many participants stayed beyond this time to continue the conversation.

## **PCK 2: Undergraduate Curriculum Innovations in the College of Chemical and Life Sciences**

This workshop began with faculty members from the College sharing their experiences in implementing curriculum changes and coordinating these changes across courses. The majority of the workshop was dedicated to a case study activity in which participants simulated the process of building a new course. This activity was adapted from a Project Kaleidoscope (PKAL) case study created by Daniel F. Sullivan on how to revise course curriculum ([www.pkcal.org](http://www.pkcal.org)). The 90-min workshop is outlined below and described in the pages that follow.

- 1. Faculty Experience and Research (30 min)**
- 2. Case Study—Lark University**
  - (a) Part I: Discussing the proposed curriculum change (25 min)**
  - (b) Part II: Implementing the curriculum change (25 min)**
- 3. Closure and Open Conversation (10 min)**

### **1. Faculty Experience and Research**

Two groups of faculty members shared examples of how they have worked with their peers who teach connected courses to change curriculum across these courses. The presenters shared different facets of the curriculum change process and how the collaboration with their peers supported student learning progressions across courses.

*Introductory Chemistry Courses:* The first group discussed the initiative undertaken by the Chemistry and Biochemistry department to change the sequence of introductory general and organic chemistry courses. They described key aspects of the curriculum change process, including creating a task force, looking at effective practices in other institutions, and involving the entire departmental or College community in collaborative decision-making. The presenters also shared important considerations in weighing potential curriculum changes. These considerations include implications in terms of the GTA work force, availability of lab spaces, and the availability and cost of textbooks appropriate for the proposed sequencing.

*Sequence of Undergraduate Courses with a Focus on Host Pathogen Interactions:* The second set of presenters shared how a group of faculty members with shared research on Host Pathogen Interaction (HPI) collaborated to change the curriculum across a sequence of nine undergraduate courses that they teach. The presenters explained that their overarching goals were to create bridges between the nine courses, eliminate excessive overlap across courses, and structure curriculum such that concepts and ideas introduced in one course become the foundation for concept development in successive courses. The presenters also discussed how, in order to develop such a continuum between the courses, the HPI community not only worked on curriculum but also on teaching approaches and rigorous assessment to promote concept development. To measure students' concept understanding, the

group developed the HPI Concept Inventory that centers on a set of 13 concepts considered fundamental to the understanding of HPI (Marbach-Ad et al., 2007, 2009, 2010).

## 2. Role Play/Case Study—Lark University

### (a) Part I: Discussing the proposed curriculum change

Workshop participants split into groups of approximately seven to engage in a case study about a proposed curriculum change initiative in the fictional Lark University (see Case Study in box).

#### **Lark University Case Study**

Lark University decided to put increasing emphasis on excellence in teaching and learning in all sciences. The University strives to be a world leader in science education among research intensive universities. Therefore, they would like to completely overhaul the undergraduate science curriculum. The dean is looking for proposals. There is a limited amount of money and all the science departments can compete for the funds. Dr. Sparrow decided that he wants to submit a proposal to change the SCI 381 undergraduate course called “Transforming the transform.”

Dr. Sparrow will teach SCI 381 for the first time next semester. He received the textbook from last year, the old syllabus (which hasn’t changed for the last ten years), and the old exams. The old course format was three 50-min lecture periods, one 50-min discussion session, and one three-hour lab per week.

Dr. Sparrow will teach his version of the SCI 381 course in parallel to Dr. Loon, who taught the course last year. Dr. Loon reported that over the past five years students have complained that the course lectures were not interesting and the material was way over their heads. The course has a prerequisite of SCI 212 (called “Those who transform-transform”) that Dr. Falcon has taught for several years.

A group is meeting to discuss submitting a curriculum proposal to the dean. Around the table are Dr. Sparrow, Dr. Loon, Dr. Falcon, the SCI 381 discussion session GTA (Beak Humming), an undergraduate student who took the course last year (Wing Stork), the lab coordinator (Dr. Feather) and the department chair (Dr. Osprey).

*Adapted from PKAL Loon University Case Study, Daniel F. Sullivan ([www.pkal.org/documents/Vol4LoonUniversity.cfm](http://www.pkal.org/documents/Vol4LoonUniversity.cfm))*

After familiarizing themselves with the case, participants discussed the proposed initiative, with each acting as one of the seven key players: the instructor who sought to change the course, two instructors of related courses, the GTA and lab coordinator associated with the course, an undergraduate student who had previously taken the



course, and the department chair. This discussion revolved around three central questions:

1. What things do you need to consider in changing a course?
2. Who should be involved in making changes to the course?
3. What will be the role of each key player?

Following the small group activity, each group reported how they responded to the three questions.

#### **(b) Part II: Implementing the curriculum change**

The small groups then reconvened and each group was instructed to think through the process of implementing the course change after the suggested initiative received funding. They discussed the steps that the course change would require, priorities in this process, and the sequence of change. To guide this discussion, each group was given the following prompt:

Good news—you got the funds!!! Now is the time to start making changes—but you teach the course next semester and not much time is left. So you think of going step by step:

1. What would be your top priority?
2. What would you change first?

#### **3. Closure and Open Conversation**

The entire group reconvened to summarize each small group discussion. The facilitator summarized commonalities and noted significant differences across groups. She emphasized that curriculum change requires coordination across courses and key players, and that the process should be well planned, regularly assessed, and open to revision. She then opened the floor to conversation and invited participants to suggest ways in which the College could improve curriculum and instruction.

### **PCK 3: Blended Learning: What It Is and How to Use It**

In this seminar, four panelists from across the university shared how they had successfully incorporated blended learning techniques into their own classes, and discussed their challenges and successes in doing so. The 90-min seminar is outlined below.

1. **Introduction and Definition of Key Terms (10 min)**
2. **Faculty Experience with Blended Learning (40 min)**
3. **Questions for the Panel (20 min)**
4. **Open Conversation (20 min)**

## 1. Introduction and Definition of Key Terms

At the start of the seminar, the facilitator provided a definition of blended learning and an overview of what constitutes blended learning.

## 2. Faculty Experience with Blended Learning

The panel consisted of four presenters who shared their experiences in planning and using a blended learning approach. Because of the diverse classes that they taught, each panelist described the context of their courses as well as how blended learning fit into that context.

The first panelist, a professor in the Department of Kinesiology, described how he flipped his large enrollment class (about 200 students) using blended learning techniques. While his previous model consisted of holding two face-to-face lecture sessions and one discussion session per week, the new model included one face-to-face lecture session, one discussion session, and one online lecture per week. In this new format, students were responsible for learning more content outside of class and had access to a variety of supplemental resources (e.g., recorded lectures, podcasts, a curated list of relevant papers and websites, and optional course textbooks). Before each face-to-face lecture, students took an online quiz that served as a formative assessment to give them and the instructor feedback on their understanding of the content. This also incentivized students to learn the material. The lecture session was then devoted to discussion of key concepts and principles, with a focus on any concepts that students had difficulty with, as indicated by the quizzes. Flipping the responsibility for learning basic content to outside of class created time for activities and inquiry-based learning during face-to-face class meetings.

The second and third panelists described how they incorporated blended learning into a molecular biology course enrolling about 60 students. Each of the panelists teaches this course independently, in different semesters. The second panelist described their process for collaboratively defining what content should be covered in the course and how to best distribute that content between face-to-face and online modes of instruction. She also talked about intramural funding sources that support transitions to blended learning. The third panelist shared his experience implementing this blended learning approach. He talked about the pros and cons of the new approach, and the lessons he learned in the process. He discussed how the course content, molecular biology, was well suited to blended learning because of the wide range of high quality, online resources that are available. In addition the field of molecular biology is moving to an increasing reliance on simulations, models, visualizations, and database tools that are better taught through online and multimedia instruction rather than textbooks and lectures.

The fourth panelist described how he used online video modules to supplement his teaching in a large enrollment (about 200 student) introductory chemistry class. He developed a series of 12 videos demonstrating how to solve representative problems from the course textbook. The videos were created using audio and screen capture software and posted on the course website. He explained how he evaluated the use and effectiveness of the videos through statistical analysis of student quiz and exam scores.

### 3. Questions for the Panel

Following the four presentations, we asked all panelists a series of questions:

1. What are the major components for successful blended learning that includes online teaching (e.g., class size, student profile, level of interactivity, assessment, instructor involvement, level of feedback)?
2. How did you decide which components of the class to teach through face-to-face and which components to teach through online instruction?
3. How does the content or pedagogical approach differ in each teaching method?
4. How do you integrate what is learned online into classroom instruction?
5. How have you fostered collaborative learning in online communities? What challenges have you faced in doing so?
6. What challenges have you faced in transitioning from traditional instruction to blended learning?
7. How do you assess the effectiveness of your online instruction?
8. How do you integrate assessment of the effectiveness of face-to-face and online instruction?

### 4. Open Conversation

The seminar ended with a 20-minute question and answer period. Several of those in the audience were already incorporating some elements of blended learning in the courses they taught, and they shared their experiences and asked for advice from the panel.

## PCK 4: As You Can See, But Students Don't: A Closer Look at How Students Read and Interpret Graphic Information

This workshop was led by Dr. Virginia Anderson, who was then Professor of Biology at Towson University. Dr. Anderson is an expert in assessment in science and is the co-author of the book *Effective Grading: A Tool For Learning and Assessment in College* (Walvoord & Anderson, 2010). She provided a brief overview of student assessment to serve as a foundation for the hands-on activities that followed. These activities allowed participants to build their skills in creating or evaluating assessment tools and analyzing student responses on those tools. The workshop was structured as follows:

1. **Introduction and the Importance of Assessment (20 min)**
2. **Using Different Types of Graphs and Charts as Assessment Tools (70 min)**

### 1. Introduction and the Importance of Assessment

Dr. Anderson described the role and purposes of course assessment, how course assessment can be used to measure different levels of thinking (Bloom, 1984), and strategies to increase the accuracy and authenticity of assessment. She discussed how assessment tools can be better integrated with course content to provide

valuable information for instructors as well as students. She emphasized that students take their cues as to what is important in a course from the types of assessments and the value assigned to each by the instructor. If assessments measure rote learning of disconnected facts, students will generally not be motivated to exercise higher order cognitive skills and, as a result, may face difficulties in subsequent courses or in the workplace when they are expected to think synthetically and critically.

## 2. Using Different Types of Graphs and Charts as Assessment Tools

After providing this brief overview, Dr. Anderson led a hands-on activity in which participants split into small groups to discuss strategies for helping students read and interpret graphic information. They also examined sample assessment tools and rubrics for assessing students' knowledge and skills in this area, evaluated sample student responses to identify where students had gaps in their knowledge, and discussed strategies for addressing these gaps.

### Recommended Resources

In the seminar, Anderson included material from her book, *Effective Grading: A Tool for Learning and Assessment in College* (Walvoord & Anderson, 2010), and suggested that participants could find additional examples in *Assessing Student Learning: A Common Sense Guide* (Suskie, 2010). Much like her seminar, these resources include examples and sample tools that are intended specifically for undergraduate science courses, making them particularly relevant to our audience.

## PCK 5: Identifying the Hallmarks of Effective Teaching to Create a Rubric for Peer Review of Teaching

This workshop occurred as a part of an initiative to develop and implement a new system for the peer review of teaching in the biology department. It was given as part of a mandatory faculty retreat, and all faculty members within the department were expected to participate. The workshop was led by the department chair, a peer review committee established by the chair shortly before the retreat, and TLC staff. In the weeks leading up to the workshop, the peer review committee had studied peer review processes at other universities to develop a sense of the range of possible outcomes. The workshop provided professional development for all participants in the form of conversations about what constitutes effective teaching. These conversations engendered a shared sense of ownership of the peer review process and an understanding of this process as arising from and connected to the departmental culture.

The workshop included multiple whole-group and small-group components:

1. **Pre-Workshop Reading (Independent)**
2. **Determining Goals of the Peer Review Process (70 min)**
3. **Defining Hallmarks of Effective Teaching (60 min)**
4. **Using Rubrics in the Peer Review Process (20 min)**
5. **Measuring the Hallmarks of Effective Teaching (50 min)**
6. **Developing Peer Review Process and Procedures (10 min)**

### 1. Pre-Workshop Reading

Prior to the workshop, all participants were given an annotated bibliography that summarized findings from a review of literature on the peer review process. These materials offered participants an introduction to the different ways in which peer reviews can be conducted and highlighted some peer review systems particularly appropriate for the context of a university science department. The readings also identified common goals of the peer review process, such as the need for the process to be of value not only to the faculty members who are being reviewed but also to the faculty members conducting the reviews.

#### **Peer Review of Teaching Literature Review: Key Points**

- Training in classroom observation can increase the reliability of peer classroom observation (Paulson, 2002).
- The most trustworthy observers are those who know the disciplinary content of the course being reviewed (Yon, Burnap, & Kohut, 2002).
- Peer ratings of teaching performance and materials are complimentary to student ratings in creating a very comprehensive picture of teaching effectiveness. Peer ratings also cover aspects of teaching that students are not in a position to evaluate (Berk, 2005).
- Both observers and observees value the peer observation process and believe that peer observation reports are valid and useful (Kohut, Burnap, & Yon, 2007).
- Peer review puts faculty in charge of the quality of their work as teachers (Hutchings, 1996).
- Peer reviews should not be viewed as punitive; instead, they should facilitate reflection on teaching styles, strategies, and philosophies for the benefit of increased student learning (Blackmore, 2005).

### 2. Determining Goals of the Peer Review Process

The department chair introduced the workshop and described the goal of creating a peer review process that would be sustainable and would contribute to the improvement of teaching within the department. Then, participants split into groups

of three to five to consider the goals of the peer review process. After approximately 30 min of small group discussion, each group reported out their goals. The workshop facilitator created a single list of all unique goals on the board. Each participant then identified the three goals that s/he viewed as most important by placing a sticky dot next the respective goals. At the end of this section of the workshop, the facilitator summarized the goals with broad faculty support:

1. Improve teaching effectiveness of individual faculty by providing feedback on teaching
2. Expose reviewers to a range of teaching styles and approaches, and thereby make them more aware of best practices
3. Provide information that can be used to assess and adjust, if necessary, course content for the audience or curriculum
4. Provide data for accurate and equitable decisions on tenure, promotion, and merit pay increases

### **3. Defining Hallmarks of Effective Teaching**

In this component of the workshop, participants discussed and prioritized the characteristics of effective teaching. Workshop participants again split into small groups, with the groups re-mixed from the earlier group activity to facilitate transfer of ideas between groups and allow faculty to hear the thoughts of a large number of colleagues. The format of this component was very similar to the previous component. Each group had an opportunity to create their own list of the hallmarks of effective teaching, and then reported out to the entire group while the facilitator created a list of all unique hallmarks. Again, participants used dot voting to indicate the three most important characteristics of effective teaching. Based on the results of the dot voting, the facilitator created a rank order list of the hallmarks and highlighted the twelve hallmarks receiving the most votes:

1. Demonstrate enthusiasm to inspire students
2. Engage students through active learning activities
3. Challenge students
4. Get students to think like scientists
5. Relate course material to everyday life, research, and other courses to make it more relevant to students
6. Make learning outcomes and expectations clear
7. Promote math and quantitative skills
8. Promote reading and writing
9. Revisit core concepts throughout the course and build themes across lectures
10. Provide opportunities for students to practice important skills
11. Inspire students to want to learn more about course material
12. Provide feedback to students throughout the course

### **4. Using Rubrics in the Peer Review Process**

The TLC director provided a brief overview of rubrics and how they can be used in the peer review process. She defined a rubric as a tool for communicating

expectations about quality. A rubric provides a set of criteria and standards that are typically linked to objectives that are used to assess performance. She also discussed key elements of a rubric and considerations for developing one.

### **Pros and Cons of Using Rubrics for Peer Evaluation**

#### **Pros**

- Rubrics can increase the assessee's understanding of the task and the expectations about quality.
- Rubrics can facilitate the work of the assessor and promote accurate and fair evaluation on the designated criteria.
- Rubrics can elicit quantitative and qualitative feedback for the assessee and the assessor.
- Rubrics can highlight salient strengths and weaknesses, and may also point assessees to areas in which they can improve their teaching practices.

#### **Cons**

- A rubric can diminish the breadth or depth of the evaluation process.
- An inappropriately designed rubric can be more detrimental than beneficial if it does not emphasize the desired/key elements that are being evaluated.
- The possibility that rubrics may be used beyond their original purpose (e.g., using rubrics that were designed for formative review to make high stakes promotion decisions) can create apprehension or other negative feelings about the rubric and related processes.

## **5. Measuring the Hallmarks of Effective Teaching**

Workshop participants split into four groups, with participants again mixing to form new groups. Each of these groups was assigned three of the top 12 hallmarks of effective teaching, and asked to brainstorm about methods to measure each hallmark. Each group then reported out their top three methods for measuring each hallmark. The facilitator again created a master list, and participants were invited to recommend additional methods.

## **6. Developing Peer Review Process and Procedures**

To open the discussion of what kind of process should be instituted in the department, the department chair presented an overview of processes and procedures for peer review at other universities. He raised four questions that the department should address in developing its own peer review process:

1. Who should conduct the peer reviews?
2. How often should each faculty member be reviewed?
3. How many classroom visits should the review entail?
4. Should reviewer identity be kept confidential?

All participants completed a survey to vote on their preferred process and procedures.

### **Following the Workshop**

Over the next few months, the peer review committee reconvened to review feedback from the workshop and the surveys, and to finalize the development of the peer review rubric. This rubric included many of the hallmarks of effective teaching that were identified during the workshop, and also drew heavily on suggested methods for measuring these hallmarks. The group also developed procedures for the peer review process, and in doing so incorporated the majority responses from the survey.

The peer review process was piloted over the course of a year, and faculty had the opportunity to review and provide feedback on the observation rubric. To further validate the rubric, faculty observations were compared to student end-of-semester evaluations. The rubric and procedures were revised based on the pilot and are now ready for full implementation (see Peer Review Rubric and Rubric Summary Report in supplemental materials).

#### **Feedback on the Workshop and the Peer Review Process**

Biology faculty members provided positive feedback about the workshop as well as the peer review process. Some faculty had initially questioned whether this workshop deserved three hours of their time and if developing a rubric for peer review was an appropriate activity for a departmental retreat. Afterwards, many faculty members commented that the workshop served as professional development in itself. They stated that the whole activity was relevant to them and required them to engage intellectually with topics that are generally not discussed in faculty meetings. Faculty members also provided positive feedback about the peer review process itself. Many faculty members noted that they learned a lot, not just from being observed and receiving feedback on their teaching, but also through the act of observing others and applying the rubric.

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