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Editorial

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Navigating the Landscape of Assessment

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ABSTRACT: Assessment of student learning in chemistry means grading tests, problem sets, and lab reports. Now more than ever, however, chemistry faculty find themselves being held accountable for learning outcomes in each course, competencies across the major, and designing assessment plans for program review. Reaching decisions about what to assess and how means mastering a dizzying lexicon and balancing several tensions inherent in the development of any assessment plan.

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> *[B]elieve it or not, we can't answer the most critical and basic questions about student performance and learning at colleges and that's unacceptable... Right now, accreditation is the system we use to put a stamp of approval on higher education quality. It's largely focused on inputs, more on how many books are in a college library, than whether students can actually understand them. Institutions are asked "are you measuring student learning" and they check yes or no. That must change. Whether students are learning is not a yes or no question... It's how? How much? And to what effect?*
>
> [Jay Labov, excerpted from ref 1, p 4]

Assessment. It is a buzzword or top-down mandate to some, a welcome responsibility to others. As faculty, we are expected to have assessment expertise when it comes to writing tests and grading problem sets. Increasingly, however, we are also expected to navigate the seemingly ever-expanding landscape of assessment, far beyond just tests. Formative assessment, summative assessment, program evaluation, accreditation—do you know how these differ from one another? What they share in common? Now let's add the consideration of who will we assess—an individual student? Students enrolled in one course? Majors completing the degree? And last, but certainly not least—what will we assess? Content, learning objectives, learning outcomes, enduring understandings, big ideas, competencies, 21st-century skills? And exactly what do these have to do with learning about molecules, their structure, and their properties? In conversations with your colleagues and administrators, do you increasingly feel like you need a translator who is fluent in *both* chemistry *and* assessment?

It is no wonder that "assessment" can seem like a dirty word to faculty. Wrangling the degrees of freedom in the paragraph above into a coherent department "assessment plan" is a daunting task. Nonetheless, the entire focus of assessment can be essentially reduced to answering just two questions: *What do we want our students to know? And how will we know that they know it?*

When it comes to identifying what we expect students to know and to be able to do, there is no shortage of ideas. In *How People Learn*, Bransford and colleagues[2] advocate cognitive and metacognitive skills, an organized body of knowledge that is deep and contextualized, an ability to notice patterns of information in a new situation, and flexibility in retrieving and applying that knowledge to a new problem. *Assessing 21st Century Skills*[3] cites the importance of (ref 3, p 2):

> *[C]ognitive skills (nonroutine problem solving, critical thinking, systems thinking), interpersonal skills (complex communications, social skills teamwork, cultural sensitivity, dealing with diversity), and intrapersonal skills (self-management, time management, self-development, self-regulation, adaptability, and executive functioning).*

Bauer, Cole, and Walter[4] offer a similar list specific to chemistry students: knowledge, metacognition, attitudes, practical laboratory skills, communication, interactivity, and decision-making skills. Which of these possibilities align with a chemistry course or the chemistry curriculum as a whole? Which of these are most important to you and your colleagues?

To narrow the universe of assessment possibilities, an analogy from thermodynamics seems appropriate. Sometimes we measure the system and sometimes we measure the surroundings, but whichever we measure, inferences about one can be drawn from measurements of the other. Assessment choices can be dealt with similarly. No need to measure everything in the universe. Identify a few targets that most reasonable people agree are important. Focus on measuring "that part of the system" and interpreting those results. Use these results to draw inferences about "the surroundings".

Answering the second question, namely, what evidence will we gather to determine whether students do indeed "know it", is much more challenging. When we start (or restart) our department conversations on assessment, several key "tensions" will inevitably emerge in the conversation:

1. What do we want our students to *know about chemistry* when they walk across the stage to pick up their diploma versus what "*21st-century skills*" do they need to develop?
2. What data do we want to collect about the *outcomes of our courses* versus what data do we want to collect about what's happening *in the courses*?
3. What data will we collect because it is *easy to measure* (even though it yields trivial insights) versus what data

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will we collect even though it is difficult to measure, but we choose to do so because it is *valuable to know*?

Although these "tensions" are framed with regard to courses and curricula, it is worth noting that these dichotomies exist at the program approval level as well. The third tension about measuring what is easy to measure versus measuring what is valuable to know is far more systemic than we might imagine. Consider this statement from the ACS Committee on Professional Training (ref 5, p 1):

> *Some of the approval criteria, such as number of lab hours required for certified majors or faculty contact hours are relatively easy to measure because they can be easily quantified. More difficult to evaluate are other hallmarks of an excellent program, such as the rigorous experiences required of its students.*

This same tension even exists within our tenure and promotion deliberations (ref 6, p 1):

> *Faculty ... must continually ... prioritize their efforts in ways that will improve the prospects of career advancement. The current perception is that research contributions are the most important measure with respect to faculty promotion and tenure decisions, and that teaching effectiveness is less valued--regardless of the stated weighting of research, teaching and service. In addition, methods for assessing research accomplishments are well established, even though imperfect, whereas metrics for assessing teaching, learning, and instructional effectiveness are not as well defined or well established.*

Of course, none of these "tensions" is easily resolved. The resolutions are not either/ors, but in reality, of course, both dimensions in each tension must be measured. Discussions and debates surrounding these tensions do not take place in a professional vacuum, either. For example, the ACS CPT clearly delineates a set of expectations for approved undergraduate programs.

Several resources exist within the chemistry community to conduct research on assessment and share the findings in a language that is accessible and meaningful to chemists. Growing numbers of STEM departments have hired colleagues with expertise in discipline-based education research (DBER). More than two dozen doctoral programs in the United States now have tenured or tenure-track chemists who conduct chemistry education research (CER), some with considerable expertise in the assessment of student learning of chemistry.[7] Hiring a colleague with deep content knowledge and research experiences in chemistry, who also has significant expertise in assessment and learning, can prove to be a catalytic hire for chemistry departments. A forthcoming NRC report regarding DBER[8] synthesizes the empirical research on undergraduate teaching and learning in the sciences, including chemistry, in order to guide instruction and assessment with the goal of improving student learning.

Chemists are uniquely positioned to tackle the assessment challenge, as we are equipped with a resource literally unmatched by any other STEM discipline. The ACS Examinations Institute[9] offers a suite of assessment tools, some long familiar to chemists, such as the Toledo Placement Exam or the entrance exams used for graduate student placement. In this issue of the *Journal*, the ACS Examinations Institute unveils a new resource, the Anchoring Concepts Content Map (ACCM), for chemistry faculty to use as they navigate the complicated landscape of assessment and encounter the tensions discussed above. The ACCM begins with identifying the enduring understandings or big ideas that cut across the undergraduate chemistry curriculum, then drills down to course-specific knowledge in each of the subdisciplines. Items on the ACS exams can then be aligned with the ACCM, providing faculty a valuable resource to not only stipulate what students know, but also to collect that elusive evidence that students do in fact know what we value.

This editorial began by suggesting that all assessment issues can be reduced to answering just two questions: *What do we want our students to know? And how will we know that they know it?* Faculty typically answer these questions in the order they are asked here, focusing first on the "what" and then eventually, maybe even reluctantly, moving on to discuss the "how". The next time that assessment is an agenda item for a faculty meeting, try reversing the conversation. Start with the "how will we know" question. Ask yourself, what can a student *do* who knows chemistry? Answer this question first and then design your curriculum and assessment "backwards"[10] from there: think of it as retrosynthesizing your assessments! *What will count as evidence that our students do know chemistry? And what do we want them to know?* When is the last time you and your colleagues discussed the answers to these questions?

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Notes

Stacey Lowery Bretz conducts chemistry education research, with expertise in both inquiry learning and assessment. She has been a member of the Board of Trustees for the ACS Examinations Institute since 2002, serving as Chair of the Board since 2009.

■ REFERENCES

(1) Labov, J. The Intersection of STEM Assessment, Accountability, and Education Policy: A "Gathering Storm" for Higher Education? In *Proceedings of the National STEM Assessment Conference*, Washington, DC, October 19–21, 2006; Deeds, D., Callen, B., Eds.; Drury University: Springfield, MO, 2007.

(2) Bransford, J. D.; Brown, A. L.; Cocking, R. R. *How People Learn*; National Academy Press: Washington, DC, 1999.

(3) National Research Council. *Assessing 21st Century Skills: Summary of a Workshop*; National Academy Press: Washington, DC, 2011.

(4) Bauer, C. F.; Cole, R.; Walter, M. F. In *Nuts and Bolts of Chemical Education Research*; Bunce, D., Cole, R., Eds.; Oxford University Press: Oxford, U.K., 2008.

(5) American Chemical Society Committee on Professional Training. Promoting Rigor in the Undergraduate Chemistry Curriculum. *CPT Newsletter* **2011**, *9* (1); http://portal.acs.org/preview/fileFetch/C/CNBP_028970/pdf/CNBP_028970.pdf (accessed Mar 2012).

(6) National Research Council. *Developing Metrics for Assessing Engineering Instruction*; National Academy Press: Washington, DC, 2009.

(7) Bretz, S. L. Graduate Programs in Chemistry Education Research (CER). http://www.users.muohio.edu/bretzsl/GradPrograms.html (accessed Mar 2012).

(8) National Research Council, Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research. http://www7.nationalacademies.org/bose/DBER_Homepage.html (accessed Mar 2012).

(9) American Chemical Society Division of Chemical Education Examinations Institute. http://chemexams.chem.iastate.edu (accessed Mar 2012).

(10) Wiggins, G.; McTighe, J. *Understanding by Design*, 2nd ed.; ASCD: Alexandria, VA, 2005.

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