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Editorial

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Testing in a Traditional General Chemistry Course

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ABSTRACT: Testing and assessments in a traditional general chemistry course are discussed. Effective student learning depends on instruction that assesses student conceptual understanding in addition to the content and applications that are often used to demonstrate the idea. Instructors are encouraged to evaluate the breadth of student learning.

KEYWORDS: *General Public, High School/Introductory Chemistry, First-Year Undergraduate/General, Testing/Assessment*

Teaching general chemistry in a large lecture venue has its challenges. You might not want to read more so the first question to consider is what constitutes a large lecture. Your Editor served as a discussion leader for various sessions during the University of Iowa College of Arts and Sciences faculty orientation at which that question elicited responses that ranged from 40 to 400. The tradition in chemistry (as well as other STEM disciplines) typically has us answering on the high end of that range; the actual number may vary but often represents the largest classes on our individual campuses. How we got to this point, or more importantly, how we get out of this dilemma may be a topic for another time. What we do to test students served in these courses has been troubling your Editor for some time, so some background is provided first.

The University of Iowa implements a team-teaching model for the 1000 or so students in the first semester of general chemistry. Because one goal is to have all students being served by the same instructor for a set of topics, it stands to reason that such a program would also use common hour examinations. Those exams happen to be multiple-choice questions with some manipulations implemented to deter collusion on the part of students. To commandeer the necessary space on campus, several of the campus' largest auditoria are utilized late in the evening. (Note that an exam time of 8:30 to 10 p.m. might actually be late at night for some individuals.) If one reflects on these conditions, several well-intentioned goals give rise to less than optimal circumstances. To begin, there is the whole idea of multiple-choice questions and their shortcomings, although current first-year college students have seen this format throughout their assessment-focused formative years. Hold that thought while another scenario is described.

The University of Georgia has been using computer-based testing for almost two decades: in part, to expand the formats and types of questions, but also to manage the logistics of administering 1750 first-semester general chemistry hour exams per testing cycle. A proctored computer lab, complete with secure software or a lock-down browser, is quite effective as an alternative to late night exams, although other logistics have their challenges. (Think about how many workstations, exam sessions, and question pools one might need to accommodate the numbers of students.) Starting with JExam,[1] software created in-house and then populated with thousands of questions in a myriad of formats over many years, the general chemistry program recently switched to a commercial, browser-based system hosted by the electronic homework vendor WebAssign.[2] The latter allows programming scripts (in PERL), arrays of data, and other features that provide breadth and novelty essentially limited only by the imagination and skills of the question writers and programmers.

In effect, at UGA we have replaced the shortcomings of late-night, multiple-choice exams with a completely new set of logistics issues. It is interesting to note that many Iowa students believe their ultimate success was limited by paper exams with multiple-choice questions while their Georgia counterparts revile the computer-based alternatives, delivered in a host of formats. Many of the UGA students speak longingly for the multiple-choice option on paper. Perhaps setting up a Facebook page for both groups would let them read each others' comments and come to a better appreciation of the source of their woes. But what about this professor, who experienced both systems? As a proponent of the use of technology (beyond paper, pencil, and Scantron sheets), the current status suits me quite well. The problem is the realization that my concerns (and perhaps the students' issues) are likely to arise from *what* we assess.

It is certainly cliché to say that students will only study what is tested. A discussion of best practices in testing should turn to the need and desire to evaluate conceptual understanding. But students need to know some descriptive chemistry and applications to help illustrate just what those concepts explain, and it is the overlap of content knowledge with higher levels of understanding that presumably leads to a mix of examination questions. Studies with evidence[3,4] strongly support the need to have students write explanations as they construct their knowledge; the idea of students practicing their chemically based rhetoric is not new and is certain part of the basis of "recitation" sessions, whose origins predate the collection of evidence to support the claim. This is where "large lecture" trumps the value of an experience like writing; a single instructor with a class of 80 may claim time restraints, while a 2000-student program with a host of teaching assistants might claim uneven quality control in grading as a deterrent. Strategies to include assessment of understanding while using multiple-choice questions have been demonstrated by Treagust

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and colleagues,[5] who used paired questions in which the first evaluates the phenomenon while the second probes the reason.

To promote effective learning, we must all endeavor to focus on the best practices of assessment, particularly testing methods and applications that are supported by evidence. The best solution might not be the easiest to implement. My reflections that led to this editorial convince me that our individual vigilance is essential. Not all will agree on a single strategy, but all instructors should make sure that their students can demonstrate knowledge beyond simple skill and algorithms.

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Notes

Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

REFERENCES

(1) JExam was designed, programmed, and implemented at the University of Georgia by Charles "Butch" Atwood, Joel Caughran, and co-workers.

(2) For a description of WebAssign, see: https://www.webassign.net/ (accessed Dec 2014).

(3) (a) Cooper, M. M. Writing: An Approach for Large-Enrollment Chemistry Courses. *J. Chem. Educ.* **1993**, *70* (6), 476−477. (b) Cooper, M. M.; Corley, L. M.; Underwood, S. M. An Investigation of College Chemistry Students' Understanding of Structure−Property Relationships. *J. Res. Sci. Teach.* **2013**, *50* (6), 699−721. (c) Becker, N. M.; Cooper, M. M. College Chemistry Students' Understanding of Potential Energy in the Context of Atomic−Molecular Interactions. *J. Res. Sci. Teach.* **2014**, *51* (6), 789−808.

(4) Xu, H.; Talanquer, V. Effect of the Level of Inquiry of Lab Experiments on General Chemistry Students' Written Reflections. *J. Chem. Educ.* **2013**, *90* (1), 21−28.

(5) For example, see: Peterson, R. F.; Treagust, D. F.; Garnett, P. Development and Application of a Diagnostic Instrument to Evaluate Grade-11 and Grade-12 Students' Concepts of Covalent Bonding and Structure Following a Course of Instruction. *J. Res. Sci. Teach.* **1989**, *26* (4), 301−314.