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The ACS Exams Institute Undergraduate Chemistry Anchoring Concepts Content Map I: General Chemistry

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Supporting Information

ABSTRACT: To provide tools for programmatic assessment related to the use of ACS Exams in undergraduate chemistry courses, the ACS Exams Institute has built a content map that applies to the entire undergraduate curriculum. At the top two levels, the grain size of the content classification is large and spans the entire undergraduate curriculum. At the bottom two levels, the grain size of the content is more fine and tuned to specific course levels of the curriculum. This paper presents all four levels of the map as identified for first-year general chemistry.

KEYWORDS: *First-Year Undergraduate/General, Curriculum, Testing/Assessment*

For a variety of reasons, chemistry instructors at the university level are increasingly interested in ways to contribute to program assessment. In some cases, departments have moved toward outcome-based learning objectives in response to the most recent program approval process from the American Chemical Society (ACS) Committee on Professional Training (CPT).[1] In other cases, the goal is to satisfy university-level reporting requirements associated with an accreditation process.[2] Chemistry faculty on many campuses have taken advantage of the long-standing system within chemistry for nationally normed exams via the ACS Examinations Institute (ACS-EI) of the ACS Division of Chemical Education. As more instructors in chemistry courses begin to use these tests in their assessment efforts, the ability to garner more information than comparative performances of their students relative to a national sample becomes increasingly useful. The content map, provided here for general chemistry, is a step that will enhance the effort to provide more information to users of ACS-EI, particularly when considered in terms of longitudinal studies of students as they progress through the four-year undergraduate chemistry curriculum.

This article reports on the ACS-EI Anchoring Concepts Content Map (ACCM) as articulated for general chemistry. The process by which this content map was constructed is reported elsewhere.[2] The salient organizational strategy follows from the concept that a limited number of anchoring concepts, or "big ideas", arise within the content of chemistry. These anchoring concepts provide the top level (level 1) of a four-level outline of the content. Level 2 of this outline includes foundational understanding of the anchoring concepts. Within some curricular paradigms,[3,4] they are referred to as "enduring understandings", and at this level of detail, the concepts still span the entire undergraduate curriculum. At the individual course level, however, the manner in which enduring understandings are emphasized may vary. Indeed, not all enduring understandings appear in every course, so an additional level of the map is warranted. As a result, level 3 of the ACCM has been identified for the subdisciplinary articulation of the approach a particular course takes to describe the enduring understandings. Finally, most courses are predicated on the learning of content at some level of detail, and the final level, level 4, of the ACCM provides this fine-grained detail for the course being mapped, in this case general chemistry. As was true for the level 2/level 3 demarcation, in some cases the grain size of the details of content covered in a course does not differ significantly from the level 3. Thus, not every level 3 articulation requires additional fine-grained detail statements at level 4.

USES AND PHILOSOPHY OF THE ACCM

At this point, it is also important to describe what the ACCM provides and what it does not provide. First, the goal of this map is to focus exclusively on chemistry content. It makes no attempt to identify keys skills related to problem-solving, critical thinking, or applications of content to new areas. The omission of these ideas does not imply they are unimportant or not incorporated in the undergraduate curriculum, but rather that they lie along a different vector in the analysis of how student learning is assessed. In a similar way, efforts to categorize test items as conceptual, algorithmic, or recall can be measured in an independent category,[5] not inherently tied to specific content, the target of the efforts reported in the current project. The ACCM is built to provide a measure of the chemistry content, one that has the key flexibility of spanning (at levels 1 and 2) the entire undergraduate chemistry curriculum.

Second, the ACCM is not a concept map in the sense that this term has been used to describe pedagogical[6,7] and assessment strategies[8,9] for student learning. The ACCM is strictly hierarchal and there is no attempt to describe the connections between the various levels (as would be done in a concept map) other than to indicate that concepts at higher

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levels are in some way articulated with more fine-grained detail at the lower levels to which they are connected.

Finally, the ACCM is not designed as a suggested curriculum. Rather, the ACCM presented here is designed to fully span the content that routinely appears in general chemistry exams produced by ACS-EI. In so far as these exams are created by committees of educators teaching the course,[10] the ACCM is likely to span the chemistry content taught in many or most college general chemistry courses. Indeed, by design, it is not expected that any course covers the entire breadth of the content as encompassed in this ACCM for general chemistry.

Another key aspect of the ACCM is that ACS-EI does not expect it to be a static tool. As noted below, the current ACCM reflects a long development process with input from many chemistry educators. Nonetheless, it is likely that refinements will be made continuously in the ACCM as it is used to assist those who use testing materials produced by ACS-EI. The key step of aligning these tests to the ACCM may well indicate content coverage omissions within the map that future test development committees will address with additions or corrections to the ACCM. Moreover, educators or chemistry departments who take different approaches to general chemistry may wish to begin with this ACCM and expand it to include their unique approaches. All of these uses are appropriate, and thus, it is anticipated that, even though the current map is the result of considerable effort and debate, it represents a starting point more than an end point.

■ ACCM DEVELOPMENT PROCESS

The process by which the various levels of the ACCM presented here were determined for describing the content of undergraduate chemistry involved focus groups sessions held at various meetings and conferences. Table 1 provides a listing of the sessions that contributed to the general chemistry ACCM specifically. The development efforts described here are designated in terms of the levels that were considered by the group that participated in each specific workshop or focus group. Thus, initial efforts were at the "top" of the ACCM, level 1 (anchoring concepts) and level 2 (enduring understandings) both of which span the entire undergraduate curriculum. The earliest statements in these levels were occasionally edited as progress was made on lower levels, but when the table indicates work or testing is done on level 3 (subdisciplinary articulation) or 4 (content details), those sessions were predominantly spent working at that grain-size for consideration of the content. Significant work was often required between sessions to merge comments from various participants into a new version of the map. At one step, the identification of level 4 statements, this task also included research into content coverage as represented by roughly 10 current general chemistry textbooks. Because of this extra activity, this in-house step at the Exams Institute is included in the timeline provided in the table.

Table 1. Summary of Workshop and Synthesis Activities for the Construction of the General Chemistry ACCM

Meeting or Conference	Date	Focus Group Activities
ACS National Meeting	March 2008	Level 1 and Level 2 synthesis
Biennial Conference on Chemical Education	July 2008	Level 3 synthesis
		Testing and refinement of Level 3 by independent group
ACS National Meeting	March 2009	Level 4 brainstorming
		Testing and refinement of Level 3
Exams Institute Office (staff)	June and July 2009	Synthesis of Level 4 statements from initial brainstorming session
ACS National Meeting	August 2009	Testing and refinement of Level 3 and of Level 4
ACS Regional Meeting (NERM)	October 2009	Testing and refinement of Level 3 and of Level 4
ACS National Meeting	March 2010	Testing and refinement; alignment of items for first- and second-semester exams
ACS National Meeting	August 2010	Testing and refinement; alignment of items for first- and second-semester exams
ACS National Meeting	March 2012	Testing and refinement; alignment of items for full-year exam

With the ACCM providing the organization, ACS Exams items can be aligned to the content statements that are articulated in the map. This alignment process for general chemistry tests is ongoing and will be reported separately. This step is important because, from the perspective of the Exams Institute, the goal of this project is to provide a way to use information from assessments. The ACCM is not meant to suggest topics for appropriate or preferred content coverage. Once again, expectations are that this map will be more exhaustive than any course might be expected to cover, yet by providing the organizational template at this scale, the chances are improved that the ACCM will be able to capture nearly all of what is taught. The intent is that it certainly captures all the content that is measured by an ACS Exam in the course, in this case general chemistry.

Because the ACCM itself is long, this introduction is intentionally brief. The map is presented in the online Supporting Information with no further elaboration. As noted earlier, the process by which it has been vetted, suggestions for how those involved with assessment efforts may use the ACCM, and other details can be found elsewhere.[11] The ACCM itself is presented in outline form in the online Supporting Information associated with this article.

■ ASSOCIATED CONTENT

Supporting Information

ACS-EI Anchoring Concepts Content Map as articulated for general chemistry. This material is available via the Internet at http://pubs.acs.org.

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Notes

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■ REFERENCES

(1) American Chemical Society Committee on Professional Training. Undergraduate Professional Education in Chemistry. http://portal.acs.org/portal/PublicWebSite/about/governance/committees/training/acsapproved/degreeprogram/WPCP_008491 (accessed Mar 2012).
(2) Volkwein, J. F. *New Direct. Inst. Res.* **2010**, *nS1*, 101−109.
(3) Huff, K.; Steinberg, L.; Matts, T. *Appl. Meas. Educ.* **2010**, *23*, 310−324.
(4) McTighe, J.; Thomas, R. S. *Educ. Leadership* **2003**, *60*, 52−55.

(5) Smith, K. C.; Nakhleh, M. B.; Bretz, S. L. *Chem. Educ. Res. Pract.* **2010**, *11*, 147−153.
(6) Earl, B. L. *J. Chem. Educ.* **2007**, *84*, 1788−1789.
(7) Regis, A.; Albertazzi, P. G.; Roletto, E. *J. Chem. Educ.* **1996**, *73*, 1084−1088.
(8) Pendley, B. D.; Bretz, R. L.; Novak, J. D. *J. Chem. Educ.* **1994**, *71*, 9−14.
(9) Francisco, J. S.; Nakhleh, M. B.; Nurrenbern, S. C.; Miller, M. L. *J. Chem. Educ.* **2002**, *79*, 248−257.
(10) Holme, T. *J. Chem. Educ.* **2003**, *80*, 594−596.
(11) Murphy, K.; Holme, T.; Zenisky, A. Caruthers, H. Knaus, K. *J. Chem. Educ.* **2012**, *89*; DOI: 10.1021/ed300049w.