

# Updating the General Chemistry Anchoring Concepts Content Map

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## Supporting Information

**ABSTRACT:** The previously published Anchoring Concepts Content Map (ACCM) from the ACS Examinations Institute is updated. Through the development process of the ACCM for other subdisciplines, changes have been made at the top two levels, and these changes need to be reflected in the previously published maps. In addition, a large-scale project to align test items from ACS Exams over the past 20 years revealed specific omissions in the initially published General Chemistry ACCM.

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

## INTRODUCTION

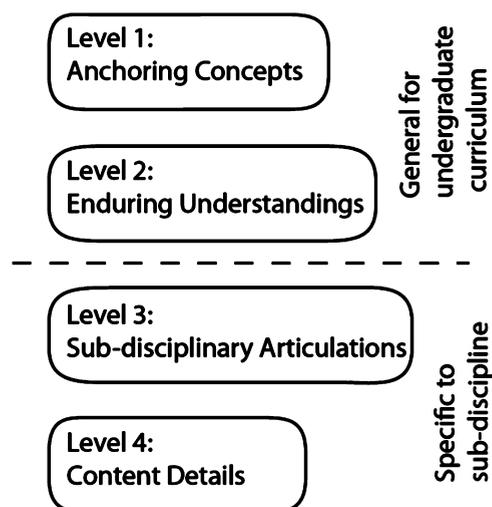
The American Chemical Society Examinations Institute (ACS-El) has engaged in a project to provide a means to map chemistry content in the undergraduate curriculum. A key motivation for this project lies in the ability of chemistry departments to utilize the resulting map to help organize assessment efforts they may undertake. Survey evidence suggests<sup>1,2</sup> that most departmental assessment efforts are externally motivated. As a result, it appears that chemistry educators benefit from efforts to organize the manner in which content learning is achieved. This need for tools represented the primary motivation for the development of the Anchoring Concepts Content Map (ACCM).

At this point, several publications have presented information about the mapping process and the initial maps that have been established. A description was provided of the workshops that were used, along with the specific motivations related to organizing content along anchoring concepts, or “big ideas”.<sup>3</sup> Specific insights into how items are aligned within the ACCM have also been described.<sup>4</sup> Importantly, the first two versions of the map, for general chemistry<sup>5</sup> and organic chemistry,<sup>6</sup> have been published.

From the outset of the process, it was recognized that the ACCM would benefit from constant updating. Even with a large number of focus group sessions to vet the map, chemistry concepts were found to be missing and organization changes were needed to help reflect the needs of other chemistry subdiscipline areas. As a result, this communication presents a set of changes that have been made in the General Chemistry ACCM since the original publication.

## PROCESS AND CHANGES

As has been noted earlier,<sup>3–6</sup> the overall character of the ACCM is described in Figure 1. Importantly, this version of the illustration emphasizes that the top two levels of the ACCM, the Anchoring Concepts and Enduring Understandings, are consistent across the undergraduate curriculum. Because the ACCM is continuing to be developed for additional subdisciplines within chemistry, there have been a small number of changes in these top two levels of the map.



**Figure 1.** Levels of the ACCM depicting the consistency of the top two levels and the specialization of levels 3 and 4.

There are minor wording changes in the Anchoring Concepts; in addition, there have been a handful of changes in the Enduring Understandings as a result of continued development of the ACCM. These include (a) two statements under structure and function that more completely articulate the connection between structure and atoms or chemical bonding; (b) periodic trends that were previously represented only within the “atoms” anchoring concept and now have additional enduring understandings, one in structure and function and a second in reactivity; (c) changes within the big idea on experimental observations to include the concept that most samples encountered are mixtures and notably to include the importance of laboratory safety; finally (d) changes in the enduring understanding level descriptions associated with visualization. (See the Supporting Information.) Each of these changes arose from the refinements that were proposed when considering the larger ACCM through the lens of experts in other subdisciplines.

The second process that led to changes in the map was a large-scale alignment process that determined what approximately 2000 ACS-EI general chemistry items were testing.<sup>7</sup> Aligned items came from exams released since 1989. Unsurprisingly, this process revealed cases where items, particularly from older exams, were not aligned with any statements in the original map. As a result, a substantial number of statements were added at levels 3 and 4 (subdisciplinary articulations and content details). These additions allowed all items in the over 20 year sample to be placed in the context of the ACCM.

One emerging use of this content map lies in an application of artificial intelligence based word search algorithms to help chemistry instructors find matches between their own test items and the ACCM. Because of this potential future use, the idea of borrowing vocabulary from computer science provides an additional description of a level 4 statement as a “node” within the map. Using this vocabulary, the change in the overall structure of the ACCM is shown in Table 1. This table includes

**Table 1. Summary of Changes Made at Level 4 of the General Chemistry ACCM**

Anchoring Concept	Number of Level 4 Nodes	
	Initial	Updated
I. Atoms	28	41
II. Bonding	15	21
III. Structure/Function	9	23
IV. Intermolecular Forces	16	28
V. Reactions	19	27
VI. Energy	24	31
VII. Kinetics	11	21
VIII. Equilibrium	14	24
IX. Measurement and Data	8	36
X. Visualization and Scale	2	11

both the total number of nodes per anchoring concept and the new nodes added in this update. As can be seen, 52.1% of the nodes either are new or have been significantly refined in this version of the ACCM. In several cases, multiple nodes have been added because a level 3 statement (higher in the organizational scheme of the ACCM) was added. The single largest area for the addition of level 4 nodes arose in laboratory safety, for example, an area that had been missing in the original version of the General Chemistry ACCM.

Another apparent, and arguably positive, change in the ACCM is a sense of balance in the content across anchoring concepts. In the original ACCM the areas of “Structure/Function”, “Measurement and Data”, and “Visualization and Scale” included substantially fewer level 4 statements. The updated version has better overall balance, and only the “Visualization and Scale” anchoring concept is notably less populated than the other big ideas.

It is also important to reiterate that the extent of the ACCM, which has increased notably in this updated version, is intentionally greater than would be associated with a single 2-semester course sequence of general chemistry or a single ACS general chemistry exam. The map is, by design, broader than would be sensible to include in a course or an exam. Because of the use of the ACCM with a historical database of ACS Exam items, it is capable of aligning with dozens of exams rather than being designed for a single exam.

The revised ACCM is provided as Supporting Information with this manuscript. Even with the large number of refinements

included in this version, there is no reason to expect that this version is going to be complete and static. As the remainder of the maps for other subdisciplines are completed, there remains the possibility of changes in the level 2, enduring understanding, statements, for example. These changes inherently require all previous versions of the ACCM to be revised, even those outside the specific subdiscipline that identifies and articulates an important new enduring understanding for the undergraduate chemistry curriculum. In addition, new curricular guideline ideas such as the Next General Science Standards (NGSS)<sup>8</sup> are likely to lead to new forms of assessment, which may well require revisions in the ACCM. The NGSS, in particular, bring up the question of whether or not “science practices” deserve a specific incorporation into the ACCM or any form of characterizing an undergraduate curriculum. Even with these potential changes on the horizon, the extent of refinements incorporated into the current version of the ACCM is substantial. As such, it seems prudent to provide this updated version at this time and recognize that further changes may yet arise.

## ■ ASSOCIATED CONTENT

### 📄 Supporting Information

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

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### Notes

The authors declare no competing financial interest.

## ■ REFERENCES

- (1) Emenike, M.; Schroeder, J.; Murphy, K.; Holme, T. A. Snapshot of Chemistry Faculty Members' Awareness of Departmental Assessment Efforts. *Assessment Update* **2011**, *23* (4), 1–2, 14–16.
- (2) Emenike, M. E.; Schroeder, J. D.; Murphy, K.; Holme, T. Results from a National Needs Assessment Survey: A Snapshot of Assessment Efforts within Chemistry Faculty Departments. *J. Chem. Educ.* **2013**, *90* (5), S61–S67.
- (3) Murphy, K.; Holme, T.; Zenisky, A.; Caruthers, H.; Knaus, K. Building the ACS Exams Anchoring Concept Content Map for Undergraduate Chemistry. *J. Chem. Educ.* **2012**, *89* (6), 715–720.
- (4) Murphy, K. L.; Zenisky, A. L. Developing a Content Map and Alignment Process for the Undergraduate Curriculum in Chemistry. In *Trajectories of Chemistry Education Innovation and Reform*; Holme, T. A., Cooper, M. M.; Varma-Nelson, P., Eds.; ACS Symposium Series 1145; American Chemical Society: Washington, DC, 2013; pp 79–94.
- (5) Holme, T.; Murphy, K. The ACS Exams Institute Undergraduate Chemistry Anchoring Concepts Content Map I: General Chemistry. *J. Chem. Educ.* **2012**, *89* (6), 721–723.
- (6) Raker, J.; Holme, T.; Murphy, K. The ACS Exams Institute Undergraduate Chemistry Anchoring Concepts Content Map II: Organic Chemistry. *J. Chem. Educ.* **2013**, *90* (11), 1443–1445.
- (7) Luxford, C. J.; Linenberger, K. J.; Raker, J. R.; Baluyut, J. Y.; Reed, J. J.; DeSilva, C.; Holme, T. A. Building a Database for the Historical Analysis of the General Chemistry Curriculum Using ACS General Chemistry Exams As Artifacts. *J. Chem. Educ.* **2014**, DOI: 10.1021/ed500732q.
- (8) National Science Teacher Association. *Next Generation Science Standards*, <http://www.nextgenscience.org/> (accessed Feb 2015).