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The ACS Exams Institute Undergraduate Chemistry Anchoring Concepts Content Map II: Organic Chemistry

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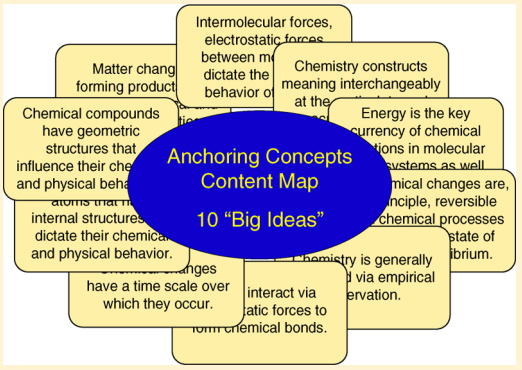
Supporting Information

ABSTRACT: As a way to assist chemistry departments with programmatic assessment of undergraduate chemistry curricula, the ACS Examinations Institute is devising a map of the content taught throughout the undergraduate curriculum. The structure of the map is hierarchal, with large grain size at the top and more content detail as one moves "down" the levels of the map, of which there are four levels total. This paper presents these four levels of the map with reference to second-year, organic chemistry.



KEYWORDS: *Second-Year Undergraduate, Organic Chemistry, Testing/Assessment*

INTRODUCTION

The role of assessment in college curricular change efforts appears to be increasingly important. For chemistry departments, the American Chemical Society (ACS) Committee on Professional Training (CPT)[1] has incorporated changes that accentuate assessment more than enumeration of courses, for example. At the scale of universities, the accreditation process[2] most faculty members ultimately help inform in some way has also undergone changes. In part because of the trends expressed by these observations, the Examinations Institute of the Division of Chemical Education of ACS (ACS-EI) has initiated several projects that are designed to provide users of ACS Exams with more information about student performance, beyond comparative information that has long accompanied such usage. One key component of these efforts lies in organizing the content of the four-year undergraduate chemistry curriculum via a content map that incorporates the content of the traditional subdisciplines of the field.

This article reports on the ACS-EI Anchoring Concepts Content Map (ACCM) as devised for organic chemistry. The map itself, in outline format, is available as Supporting Information for this article. The overall process for the development of this content map has been previously reported.[3] In order for this process to lead to a broad-based tool for considering chemistry topics, the map uses a limited number of anchoring concepts, or "big ideas", as its central organizing themes. As such, the anchoring concepts provide the broadest or "top" level of an outline of the content that ultimately includes four levels. The next level of detail uses statements of content that serve as a still broad-based foundation for understanding the big ideas of level one. Using language coined within evidence-centered design,[4,5] this level is occupied by "enduring understandings" of the chemistry concepts. Importantly, the enduring understandings are established so that they span the entire undergraduate curriculum rather than articulate specific ideas in specific courses. Nonetheless, even though the concepts ensconced as enduring understandings are argued to be foundational, within any subdiscipline of chemistry, some such concepts will be emphasized while others are not. Indeed, there is no particular reason that all enduring understandings appear in any given course. This realization ultimately requires, therefore, an additional, third level of the ACCM to be created, which has been dubbed the "subdisciplinary articulation". This level of the ACCM is where instructors of a course work to describe how the enduring understandings are considered within that course. In the portion of the map reported here, the course experts teach second-year-level organic chemistry courses. Finally, there is a level of content detail that is recognizable in virtually any course as the day-to-day information that is the focus of student learning. This level of detail is also the final level of the ACCM that provides fine-grained information about the content that may be covered in the course being mapped, in this case organic chemistry. The initial example of such a content map, for general chemistry, has been published previously.[6]

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USES AND PHILOSOPHY OF THE ACCM

It is important to recognize the ultimate goal of this process. The various components of the ACCM that are released are not designed to identify a preferred content coverage. Rather, the ACCM is designed as a scaffold that allows instructors to identify how test items measure specific content in terms of student knowledge and do so in a way that can assist in the development of models for student learning across time. The ACS-EI is undertaking an alignment process[7] for all exams it produces so that departments that examine student performance using ACS Exams will ultimately have additional information about what their students have learned as well as how they compare with national samples of student test-takers. In part because of this focused goal of organizing the content of chemistry for alignment of test items, this map makes no attempt to identify skills that are important in addition to content knowledge such as critical thinking or problem-solving. Such skills are clearly central to the overall development of undergraduate students and are a key part of overall assessment efforts, yet they are tied to content knowledge in a highly variable way.

It is possible to categorize test items in ways other than the content they test; for example, cognitive categories such as conceptual, algorithmic, or recall items.[8] Indeed, such efforts have been reported for organic chemistry items specifically.[9] Once again, the ACS-EI includes efforts along these lines in the alignment work it is undertaking. Nonetheless, the ACCM is not designed as a concept map in the way that this term has been used in previous work.[10−13] In particular, the ACCM is hierarchal in terms of the granularity of the description of chemistry content and does not explicitly describe connections between the various levels. Finally, the ACCM is being constructed via processes that are similar to the test development process for ACS-EI. Exams are created by committees of educators who teach the course for which they are designed,[14] which results in items that are well vetted (for content) and edited by groups of volunteers. The ACCM has also been vetted in a number of venues, so the manner in which the organic chemistry content is expressed reflects this process, and while it may not match identically any individual course, it provides a community-established view of what is likely the broadest possible expanse of course at this time.

In line with previously reported work,[6] the ACS-EI is publishing the organic chemistry component of the ACCM at this time, but will continue to adjust it in the future. Essentially continuous refinements will characterize the ACCM, for example, as it is used in the analysis of exams produced by ACS-EI. It is also important to note that any educator or chemistry department that wishes to try different approaches to the presentation of chemistry content may begin with the ACCM and expand it to include a unique approach.

Finally, it is worth noting that the publication of a second area of chemistry within the ACCM will naturally lead to an ability to consider structural differences among different aspects of the curriculum. More detailed analysis of such differences is underway and will be reported elsewhere, but one key difference between the general chemistry and organic chemistry maps is immediately apparent. The extent to which the ACCM for organic chemistry emphasizes chemical reactions is dramatically greater than the coverage of reactions in general chemistry. This observation is not at all surprising. It reflects with some accuracy the fact that, within the overall chemistry curriculum, the second-year-level organic courses are quite likely the place where reaction chemistry is emphasized more than any other course. This observation carries no value proposition within the development of the ACCM. Rather, it reflects the undergraduate curriculum in chemistry that has emerged over time and is largely in place at this time.

ACCM DEVELOPMENT PROCESS

It is important to recap the process used by the ACS-EI in the development of the ACCM so that any who might be interested in using it can articulate its origins. Because of the long-term programmatic goals of the ACCM, initial efforts were designed to flesh out the "top" of the ACCM, specifically levels 1 (anchoring concepts) and 2 (enduring understandings). Because these levels span the entire undergraduate curriculum, they have been repeatedly vetted further, as new groups of educators take on the task of identifying level 3 statements for particular courses. The specific identification of level 3 articulations for organic chemistry occurred in several rounds of workshops, with synthesis of suggestions done internally at the ACS-EI. Finally, in order to identify level 4 statements for comments from participants at workshops, the content coverage of organic chemistry was initially identified by scanning the coverage of six current organic chemistry textbooks.[15−20] Table 1 summarizes the overall development activity for the organic map, including in-house steps undertaken at ACS-EI.

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

Meeting or Conference	Date	Focus Group Activities
ACS National Meeting	March 2008	Level 1 and 2 synthesis
ACS National Meeting	August 2008	Level 3 initial brainstorming
Exams Institute Office (staff)	Spring 2009	Synthesis of level 3 statements from initial brainstorming session
ACS National Meeting	August 2009	Testing and refinement of level 3
Exams Institute Office (staff)	Fall 2009	Further synthesis of level 3 statements from second workshop session
Biennial Conference on Chemical Education	July 2010	Testing and refinement of level 3 and initial alignment attempts
ACS Regional Meeting (SERM)	December 2010	Testing and refinement of level 3
ACS National Meeting	August 2011	Testing and refinement of level 3, alignment of items
Exams Institute Office (staff)	Fall 2011	Establishment of initial level 4 statements
ACS National Meeting	March 2012	Testing and refinement of level 3 and level 4
Exams Institute Office (staff)	Fall 2012	Final synthesis and editing of levels 3 and 4

The establishment of the ACCM for organic chemistry now allows ACS exam items to be aligned to the content statements as noted in the map. This alignment process for organic chemistry tests is ongoing at this time. It is important to recognize that the ACCM for organic chemistry, much like the previously published version for general chemistry, is more exhaustive than any course might be expected to cover. Nonetheless, by providing an organizational template at this rather broad-ranging scale, the chances are enhanced that the ACCM can capture what is taught in most or all of the organic courses in the United States. At the least, the ACCM is

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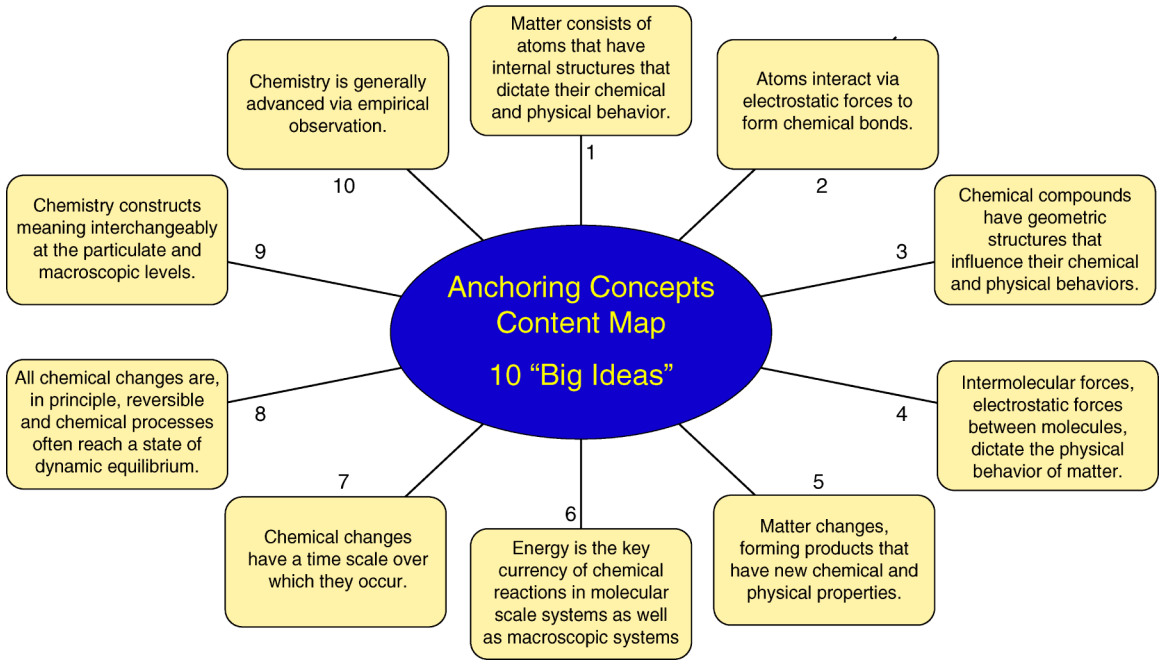

Figure 1. Statements of the 10 anchoring concepts in the ACCM.

designed to capture any content that appears in an ACS Organic Chemistry Exam.

Because the ACCM itself is long and the overall process has been previously described,[3] the description provided here for the organic chemistry map is intentionally brief. As noted earlier, the organic chemistry ACCM map itself is presented using an outline format in the Supporting Information of this article. An illustration of the 10 anchoring concepts alone is provided in Figure 1.

■ ASSOCIATED CONTENT

Supporting Information

ACS-EI Anchoring Concepts Content Map as articulated for organic 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.

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