View from My Classroom

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What Should We Teach in High School Chemistry?

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During my interaction with high school teachers at professional conferences, I have noticed disagreement about the purpose and content of high school chemistry. There seem to be two schools of thought: (i) high school chemistry is preparation for college-level chemistry, should contain introductions to essentially the same topics taught in college chemistry, and should consist of the students that are recommended for the class or that show interest and potential in science-related careers or (ii) high school chemistry is a general-education course that should provide another way for students to view the world and further interest them in science; therefore, the course should be open to all students and focus on broad conceptual understanding. The high school teachers belonging to the second group do want their students to be prepared for college-level chemistry, however, this is not their only goal. I believe in encouraging my students' understanding of how chemistry affects their everyday lives, that chemistry is not an abstract way of thinking and that they have the ability to understand the chemical aspects of the world. However, I do realize that some of my students (and their parents) are concerned about surviving a college-level chemistry course. In an attempt to accomplish both of these tasks, I set out to discover what knowledge and skills college professors feel students need to have mastered before their freshman-year chemistry course to promote success.

Literature Review

The literature on this topic is sparse and out-of-date. A dialogue regarding the benefits of high school chemistry to college students began in the 1950s *(1–4)* and again in 1987 *(5)*. These studies did not take into account what was being taught in those high school courses, only whether the course was taken. The Toledo exam was given to students in the late 1970s as a pretest to determine the topics they were lacking as they entered the university system *(6)*. Several studies are similar the one presented in this article: surveys were mailed to inquire what should be taught in high school chemistry. However, most studies surveyed students, a small number of local university or junior college staff, or did not limit participants on the number of topics they rated as important *(7–10)*. Mitchell authored two papers *(11, 12)* that analyzed questionnaires from a large number of chemical educators at both levels and found a large disagreement between high school teachers' and college professors' opinions about what should be taught in high school chemistry. Mitchell's studies asked for 73 topics or skills to be rated on a Likert scale. Finally, several papers spoke of the need for high school chemistry courses to interest students in science more than provide a miniversion of college chemistry *(5, 13–15)*.

Method

An email survey was sent to a large variety of college chemistry instructors (Tables 1 and 2). Emails were sent to approximately 300 attendees from the Biennial Conference on Chemical Education in August 2000 at The University of Michigan.

The current study differs from Mitchell's studies *(11, 12)* in that instructors were not asked to rate each topic as whether they think it is important or not—in that situation, a professor could believe that every topic is important—but instead they were asked to choose the top five topics from a list (List 1) that students needed to master prior to entering college chemistry to promote success. The instructors were also informed that this does not mean that instruction would be limited to those five topics.

Analysis

For each topic, the percentage of professors including that topic in their top five was calculated. Topics were analyzed for statistical significance between topics using analysis of variance (ANOVA). The null hypothesis was rejected and the Newman–Keuls procedure was used to determine which topics had statistically significantly higher percentage of votes than other topics *(16)*. The top seven topics were statistically significantly higher ranked than the other topics. The results of the analysis are displayed in Table 3.

Table 1. Participant Breakdown by Institution Type

Institution Type	Number of Participants
4-year	75
2-year	21

Table 2. Participant Breakdown by Courses Taught

Course	Number of Participants
General chemistry	83
Organic chemistry	32
Advanced chemistry (analytical, physical, inorganic)	47
Other (biochemistry, nonmajors, environmental, etc.)	19

NOTE: Participants were instructed to identify all courses that they teach. Some instructors indicated teaching multiple courses; therefore the total number of courses is greater than the total number of participants.

Topics that participants included in the "other" category were: bonding (types and characteristics), Lewis dot structures, writing skills, examining the plausibility of answers, connections between the macro and micro worlds, connections to real life, and descriptive chemistry. Statistics were not calculated on the frequency of these comments, as it can not be determined how many people would have chosen them in their top five if they had been listed on the survey.

Results

A survey was sent to instructors of chemistry at postsecondary institutions to gather opinions of what topics are important for students to master in high school to promote success in college chemistry. Seven topics emerged as being included in the participants "top five" a statistically significant number of times. The seven topics include basic skills (units, significant figures, graphing, etc.), moles (molar mass), dimensional analysis (factor-label method), stoichiometry, naming and writing formulas, atomic structure (parts of an atom, electron configuration), and balancing equations.

List 1. Topic List That Participants Were Asked To Rank

- Basic skills (units, significant figures, graphing, etc.)
- Dimensional analysis (factor-label method)
- Atomic structure (parts of an atom, electron configuration)
- History of atomic theory
- Classification of matter and energy, physical vs. chemical properties vs. changes
- Naming and writing formulas
- Moles (molar mass)
- Solutions and concentrations
- Enthalpy (Hess's law, heats of formation, fusion, vaporization, calorimetry)
- Gases (kinetic molecular theory, gas laws)
- Types of reactions
- Balancing reactions
- Stoichiometry
- Periodic table and periodicity
- Acid–base (pH, strength, titrations)
- Acid–base (buffers, complex titration problems)
- Kinetics (qualitative approach)
- Kinetics (quantitative approach)
- Equilibrium (qualitative approach)
- Equilibrium (quantitative approach)
- Scientific process skills (design of experiments, data analysis, etc.)
- Basic lab skills (filtering, drying, microscale, titration, gas collection, heating, measurement, use of glassware)
- Other

Although comments were not specifically solicited, many participants included comments on the project with their replies. Many professors stated that the topics, concepts, and knowledge students bring into college chemistry are not as important as the attitudes, process skills, and study skills. Comments suggested that professors would rather have students with good study habits, without fear of chemistry, and an appreciation for how chemistry affects their everyday lives.

Implications for High School Teachers

For high school teachers trying to decide which topics to include in the short time with the students, this information can prove useful. High school teachers want to prepare students for the next level of education, yet many may also want to offer a useful and interesting class for those students not going on to take college science courses. In addition, many high school teachers do not have the luxury of having two separate chemistry courses in the curriculum to address the two schools of thought discussed in the introduction of this article. By knowing which topics are most useful for success as students enter college-level chemistry, high school teachers can focus their instruction on these topics. Shortening the list of topics that must be covered in the year may provide high school teachers with the time to integrate real-world or hands-on learning in the classrooms that promote lifelong interest and understanding in science.

Table 3. Results of College Professors' Choice of Top Five Topics That High School Students Need in College Chemistry

Topic	Percent of Participants
Basic skills	82
Moles	58
Dimensional analysis	56
Stoichiometry	55
Naming and writing formulas	55
Atomic structure	44
Balancing equations	44
Lab skills	24
Periodic table	24
Solutions and concentrations	21
Process skills	20
Classification of matter	18
Types of reactions	7
Gases	5
Equilibrium (qualitative)	5
History	3
Acid–base (simple)	2
Enthalpy	2
Kinetics (qualitative)	1
Acid–base (complex)	0
Kinetics (quantitative)	0
Equilibrium (quantitative)	0

NOTE: See List 1 for the description of each topic as it appeared on the survey.

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